MILITARY SYSTEMS DESIGN

NOVEMBER-DECEMBER 1960

featuring:

New Gyroscopes

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TWO-METER POWER SUPPLY
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cover article:

First Ceramic Gyro For Space Achieves Ultra-Accuracy

ANNUAL INDEX VOL. IV 1960

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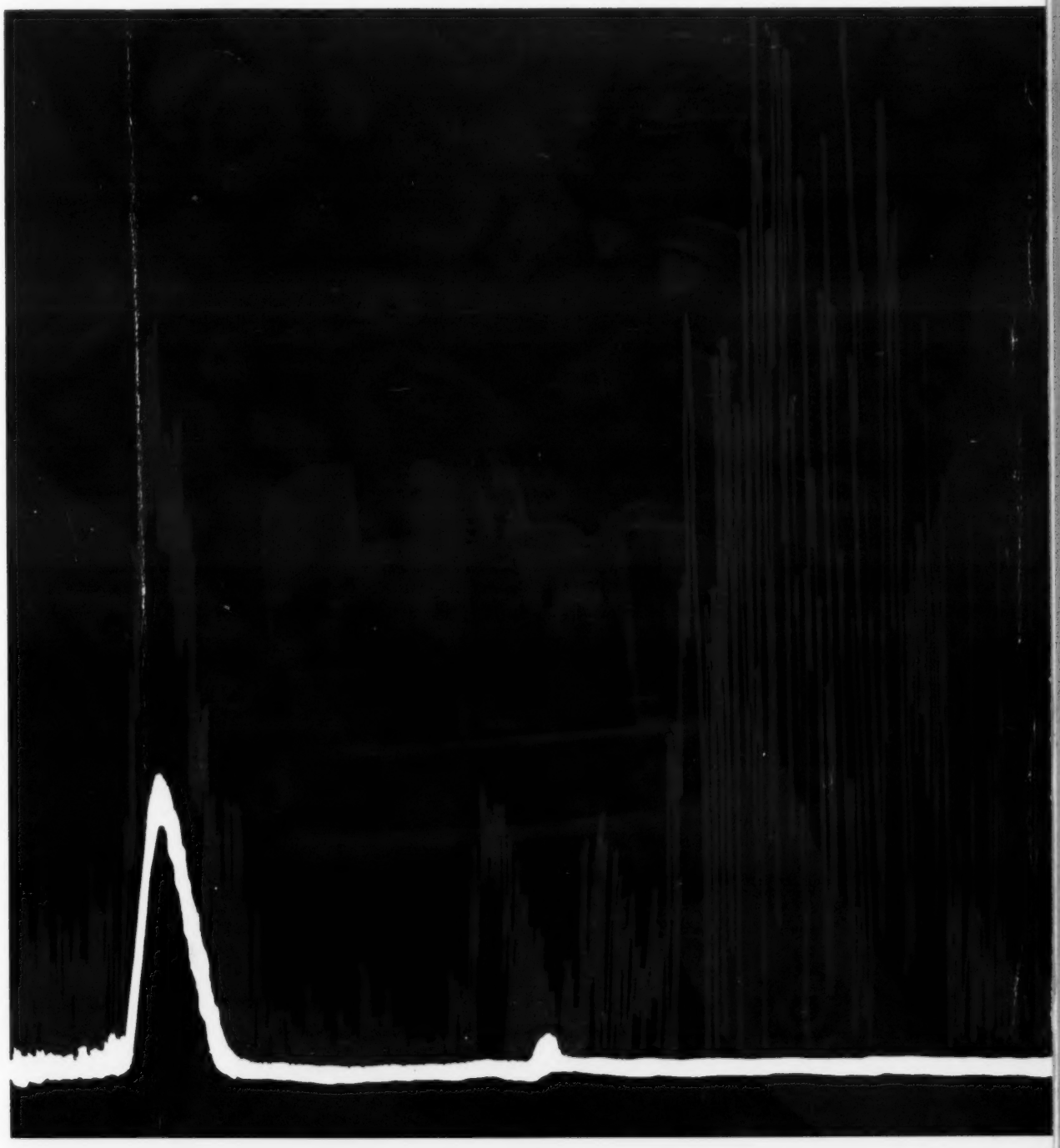

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MSD MILITARY SYSTEMS DESIGN

VOLUME 4, NUMBER 6
NOV.-DEC. 1960

COVER: Significant reduction of bearing noise achieved in new ceramic gas-bearing gyro is shown by oscilloscope comparison with bearing noise of standard MIG gyro. Noise is evidence of ball friction, a major cause of gyro drift. Miniature size of gyro rotor is also dramatically shown. (See page 4).

MSD editorial

Merry Christmas!

With this issue, *MILITARY SYSTEMS DESIGN* completes its fourth year. In these four years intensive activity in the design of electronic and electromechanical systems has made possible the manufacture and control of missiles of tremendous striking power. In this time the ICBM has come of age. With the launching of the USS GEORGE WASHINGTON the Western World attains a missile capability which is independent of bases in foreign lands and which does not offer a target for a "preventive" attack by the enemy. Capsule recovery from satellites now brings manned exploration of space only a short step away.

President Eisenhower was undoubtedly correct when he stated in the recent election campaign that the United States is the strongest nation in the world. Many of the readers of *MILITARY SYSTEMS DESIGN* can personally take credit for important contributions toward this strength. Well Done!

—And An Exciting New Year!

However, important as is the maintenance of a strong military position vis-a-vis the Russian Bloc, this is not enough. President-elect Kennedy recognizes this and has promised aggressive leadership in other important areas. His suggestion of a foreign-service corps of young technically trained men to serve in lieu of military service has great possibilities. Such service should be granted only to young persons highly qualified in every respect, and who would be good-will ambassadors for democracy.

We believe that a crop of developments resulting from space technologies is just beginning to flower. In the coming few years many methods of communication and control will be revolutionized. Business accounting and sales will be increasingly automated as will many of the more tedious chores associated with education. Electronics systems and component designers will find increasing employment in these areas.

More important than the making of better and smaller hardware, however, may be the application of broad techniques of system development and design to the problems of economic growth and management. Some possibilities of this nature are suggested by the use of computers in "War Gaming" and "Management Gaming" exercises.

We are confident that electronics and systems engineers will find 1961 exciting. We also hope that a year from now our progress measured toward a more peaceful world will tell us that it has truly been a Happy Year!

Scanning This Issue

The close dependency between new techniques and new materials is vividly illustrated in our cover article on ceramic gyros by Jack Lower, Chief Engineer in the Gyro Design Section, Aeronautical Division for Minneapolis-Honeywell. High reliability and long life for gas-bearing gyros were achieved only after development of a new ceramic for vital gyro parts. Other interesting gyro articles include a survey of their use in ballistic missiles and space vehicles by Paul Ott, Nortronics Div., Northrop Corporation, an exposition of the Magneto-hydrodynamic Gyro by R. V. Monopoli, Speidel Corporation, and a brief news item on the General Electric electrostatic gyro, which is still under security wraps insofar as detailed descriptions or illustrations are concerned. (*see below*)

Test tables for determining gyro characteristics are described by Paul Kaestner, Chief Engineer of J. W. Fecker, Inc., while two shorter articles describe a sturdy vertical gyro for target drone applications and a versatile miniature rate gyro in which angular momentum rates and gimbal deflection can be controlled to meet job requirements.

In addition to articles on inertial sensors manufacturer's literature on other types of transducers, including angle transducers, thermistors, heat-limit switches, linear and rotary pots, strain gages resolvers and underwater transducers, are briefed in this issue. The advantage of this treatment is that the interested reader can obtain this literature free on request through the MSD reader Service Card.

Other important articles cover the updating of magnetic tape information, by J. C. Hammerton, and a new mechanical energy absorber which promises to save the lives of many navy jet pilots.

Electrostatic Gyro is Space Reference

Utica, N. Y.—An electrostatic gyro developed by General Electric's Light Military Electronics Department has successfully operated in tests for 100 continuous hours, according to an announcement made here.

Developed for the Air Force by LMED engineers, the new gyro is being investigated for use in inertial subsystems aboard satellites and space vehicles. Electrostatic suspension eliminates the friction and wear problems associated with conventional rotor spin bearings, and shows promise of considerable reduction in gyro-drift characteristics.

To be practical, electrostatic gyros must provide rotor suspension in the presence of the earth's gravitational field and in other accelerations that may be encountered. In operation, precise control requires keeping the rotor at a constant potential, preferably zero. This suggests that the known low-drift potential of earth-bound electrostatic gyros can be further reduced in space or satellite applications where gravity fields and acceleration loading are at or near zero for long time periods.

Manned Space Vehicle Mon

MANNED SPACE vehicle pilots in X-15 or succeeding high-performance rocket planes will be as closely watched by monitoring teams as their highly-tuned planes. All experimental flights will be scrutinized over a space display unit being designed for the Air Force Flight Test Center, Edwards AFB, California, by the International Telephone and Telegraph Laboratories, San Fernando, Calif.

Separated into vehicular and physiological units, and console will display on the vehicular unit stability and aerodynamic parameters, structural strains, flutter, power plant behavior and various operational fault warnings which will be monitored by an experienced test flight engineer (Fig. 1). The physiological unit displays the pilot's heart rate, blood pressure, temperature, breathing rate and volume, oxygen supply, acceleration and radiation count for the consideration of the monitoring flight surgeon. The console-watching experts exercise only remote control through advice radioed to the pilot.

Because the monitored factors are displayed to show "safe/unsafe" type indications or to trace recent

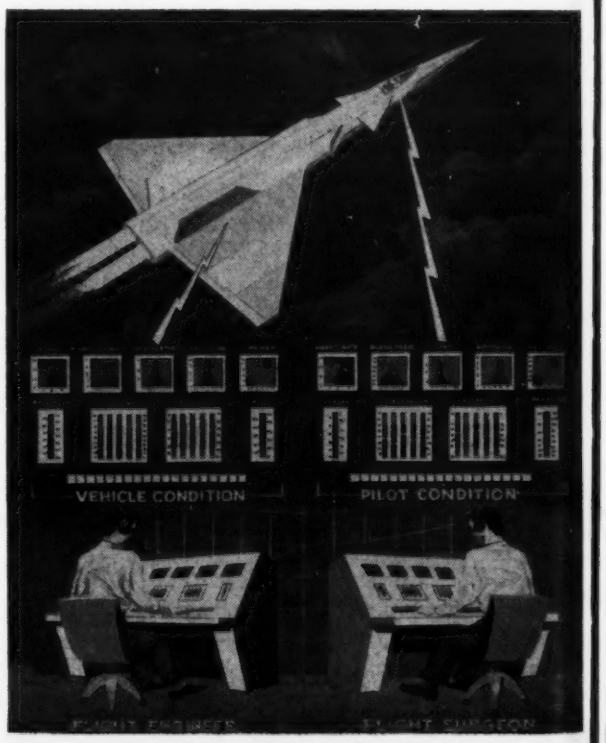

FIG. 1. MONITOR SYSTEM for X-15 Type "Inner Space" craft will be built for Edwards AFB by ITTLaboratories. Vehicle and pilot condition indications are displayed in real time on consoles.

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Monitoring Systems

history to show dangerous trends, no computers are required and all indications are in "real time." The Edwards AFB monitor will be in operation early next year.

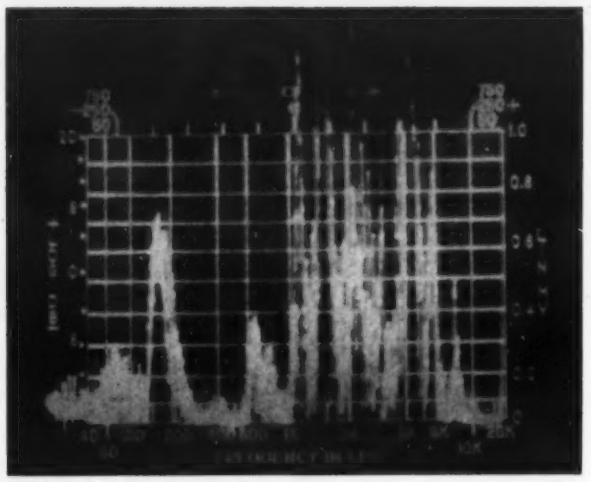
In a similar, although entirely separate project, equipment for the Flight Controller Team of Project MERCURY has been completed by Stromberg-Carlson-San Diego under subcontract from the Bell Telephone Laboratories (Fig. 2). Installed at Cape Canaveral and at the Bermuda Range Station, the display consoles will contain charts and meters to display data, switches to activate systems which control the flight and telephone intercommunications systems.

A large global map will show the manned capsule's orbiting path, location of the remote stations and displays giving critical data about each remote station. The room will contain other electronic equipment necessary for receiving and displaying data and relaying flight controller team's commands. Some direct control of rockets, aborting mechanisms, etc., is afforded by the console team in the case of the Mercury flight, to parallel or supersede those available to the astronaut.

FOR MORE INFORMATION ON: (1) IT&T MONITOR CIRCLE 95 (2) STROMBERG CARLSON MONITOR CIRCLE 96 ON READER-SERVICE CARD

FIG. 2. **MANNED SPACE CAPSULE** monitor equipment for use at Cape Canaveral by NASA's Project MERCURY is shown nearing completion at Stromberg-Carlson-San Diego plant. Bell Telephone Laboratories are prime contractors for this phase.

FIG. 1. CERAMIC spin motor of new gas-bearing space guidance gyro is being encased in ceramic gimbal. Reduction of bearing noise by 30-to-1 ratio is claimed for new bearing. Rotor is balanced by drilling out metal from band clamped between rotor end-bells.



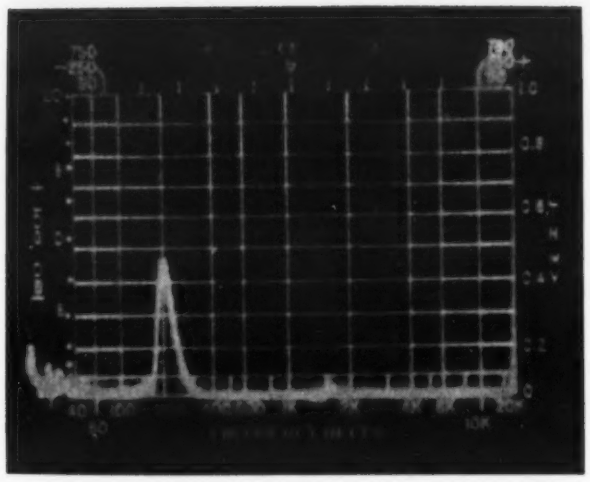


FIG. 2. NOISE-FREE quality of ceramic gas bearing is illustrated by oscilloscope comparison between (a) decibel reading from ball-bearing MIG gyro, and (b) same readings from gas bearing gyro. Peak at 200 cps is due to fundamental of rotation frequency at 12,000 rpm.

First Ceramic Gyro For Space Guidance Achieves Ultra-Accuracy

JACK W. LOWER, **Chief Eng., Gyro Design, Aero Div., Minneapolis-Honeywell**

THE AEROSPACE industry's first ceramic gyroscope, representing significant improvements in gyro accuracy, has been developed by the Aeronautical Division of Minneapolis-Honeywell Regulator Company. Designed for missile and space uses, it incorporates gas lubricated spin motor bearings.

The new gyro marks the greatest improvement in production gyros in a decade. Its development, the result of four and a half years of research, has far-reaching significance in the field of missile and space vehicle guidance.

The gyro was made possible by two major achievements: One was Honeywell's development of a ceramic material as hard as sapphire that can be diamond-honed into the tiny and ultra-precise shapes of critical gyro parts; the other, the development of a miniature ceramic self-generating gas bearing (Fig. 1).

The combination of ceramics and gas bearings has sharply reduced the prime causes of gyro drift inaccuracies, and has resulted in a gyro with a theoretical life span approaching infinity. Previously gyroscopes used ball bearings which are relatively unstable and subject to wear (Fig. 2a), as evidenced by random noise frequencies shown in oscilloscope bearing tests.

The ceramic bearings in the new gyro are lubricated by a film of gas less than 50 millionths of an inch thick. The film of gas provides a bearing that is stiffer than the steel ball bearings it replaces. At the same time vibration, or bearing noise, is decreased by a ratio of 30 to 1 (Fig 2b).

Although the principle of the gas bearing is not new, previous models without ceramics have been severely limited due to size and bearing wear caused by starting and stopping. The new gyro is only 2.817″ long and 2.0″ in diameter and weighs only half a pound. In tests its super-hard ceramic bearings have undergone many thousands of starts and stops without detectible wear. In addition to nearly eliminating the drift caused by the ball bearings, drift caused by the instability of other critical gyro parts has been reduced considerably by using ceramics in the spin motor and gimbal constructions.

Even such exotic gyro materials as beryllium have undesirable characteristics that can cause gyro drift. In stability tests of its new ceramics, Honeywell subjected the material to temperatures ranging from —85°F to 1500°F and the material retained its original dimensions within measurement accuracy. The ceramic material is so inert that Honeywell cleans it in hydrochloric acid to remove sub-microscopic foreign particles that could affect gyro performance. The acid dissolves everything but the ceramic, permitting cleaning and assembly techniques in production substantially advanced beyond the conventional use of cleaning solvents and ultrasonic scrubbing.

Ceramic gyro parts are rough cast in powdered form. The material can be worked easily in the half-fired "green"state. After final firing at above 3000°F the material becomes as hard as sapphire.

Although the ceramic is harder than ordinary grinding wheel materials, it can be finished with diamond compounds to extreme accuracy and excellent surface finish. Tolerances on some parts of the new gyro are being held to less than three millionths of an inch.

Honeywell has been conducting research in the field of close tolerance ceramics for several years and recently began full-scale commercial production of precision ceramic components for military and industrial applications.

Floated Gimbal Suspension

The ceramic gas bearing unit is the next generation in a family of gyros that began with the miniature integrating gyroscope (MIG), presently used in missile and space vehicle guidance systems. Like the MIG, the gimbal of the new gyro is floated to reduce gimbal friction torque. In a floated integrating gyro the input turning rates are converted by the gyroscopic element into gimbal torques. These torques are time integrated through a viscous fluid into gimbal displacements which may be read off directly by a displacement type pickoff.

A practical mechanization of the floated gyro principle results in a gyroscopic element (spin-motor) sealed within a cylindrical gimbal supported by a viscous fluid to obtain near friction-free support (Fig. 3).

Unwanted Gyro Torques

Two categories of unwanted gimbal torques confront the gyro designer. The first is a friction-torque that tends to mask off some lower level gyroscopic torques to limit the angular rate threshold capability of the gyro. Second is an unbalance torque that comes from other than gyroscopic action and is erroneously measured as an angular motion.

Present production floated gyros with gimbal flotation suspension reduce greatly the first category—friction torque. Flotation of the gimbal weight to better than 99 per cent has reduced friction to the order of a million times less than ball bearings. Advanced developments in hydrostatic fluid gimbal supports, magnetic suspension or electrostatic suspensions are within reach to improve this area several orders of magnitude further.

It is the second category of unbalance torques that the ceramic gas bearing spin motor significantly improve.

One of the most significant measurements of performance for a gyro is its drift uncertainty. Because the turning rate inputs to the gyro element are converted to gimbal torque, any unwanted, uncontrolled, torques applied to the gimbal cause errors to be introduced in the output response.

Unwanted torques may come from gimbal unbalance, electromagnetic reactions of pickoffs and torque generators, elastic restraint of the flex leads supplying power for the spin motor, or from the complex responses of the gyro under vibration inputs.

There is usually a fixed amount of unwanted torque in any one gyro that is consistent and repeatable and this error can be balanced out by trim adjustment with little difficulty. Magnetic restraint and flex lead elastic restraint are typical types of this fixed torque.

However, the gyro designer is still left with some unwanted torques that cannot be compensated because they are inconsistent. These inconsistent torques establish the true uncertainty level of the gyro and set performance limits for gyro drift.

Control of these inconsistent torques is where the ceramic gas bearing gyro has shown significant results. It has proved to be the solution to torques resulting from movement of the ball retainers and shifts of the balls in the race way, mechanical hysteresis effects due to material damping and ball slippage, the stress and strain of the balls under angular motions of the gyro which cause deformations that change the balance of the gyro, and mechanical rectification of the vibration set up by the ball bearings of the spin motor.

In the ceramic gas bearing gyro the troublesome balls and retainers are eliminated, viscous damping is substituted for hysteresis damping and deformations due to thermal expansion disappear. Vibration or bearing noise is decreased by a ratio of 30 to 1.

Gas such as air or helium has been found to be an effective bearing lubricant so long as the bearing geometry is proper. While the gas lubricated bearing is in operation its elements are separated by a thin film of gas (Fig. 4). Consequently there is no contact between the bearing elements and wear is negligible.

Careful choice of material for the gas bearing is necessary to provide high reliability for a number of starts and stops. Surface finish, cleanability, hardness, and stability over time and temperature cycling are extremely important factors. Application of the new ceramic material to miniature gas bearing development was a major breakthrough. Ceramics have a high modulus of elasticity and exhibit very good thermal stability and low long-term creep. These characteristics are extremely important when dimensional control and stability are essential.

The stability advantages of ceramics also make this material more attractive than metals, including beryllium, for use in other parts of the gyro such as the gimbal, coil cup, and encapsulation of the spin motor stator.

HOW THE GAS BEARING OPERATES

The gas bearing functions as a passive device capable of supporting a load on a thin film of gas without any external aids such as pressure lines or gas supplies. The basic principle of the gas bearing may be illustrated as follows. Consider a single journal bearing consisting of a shaft rotating in a concentric bearing shell as shown in Fig. 4.

As the shaft rotates, the gas within the clearance space is set into motion by the viscous shear forces of the gaseous lubricant. Pressure builds up in the direction of rotation until the minimum film thickness (h_o) is reached. At this point, throttling begins and the pressure drops off rapidly. Within the "wedge" area approaching the point of minimum film thickness, the viscous shear forces must be balanced by the pressure forces. Now, the basic mechanism for load support utilizes the principle of constant mass flow. For the journal bearing without end flow, the mass rate of flow must be constant along the axial length of the bearing. Expressed symbolically:

$$\rho v h = \text{constant}$$

where ρ = density of the gas, v = average gas velocity, and h_o = film thickness.

When the bearing is loaded, it takes an eccentric position and the film thickness varies sinusoidally around the journal. Accordingly, either the density of the gas, the velocity of the gas, or both, must vary inversely to satisfy the continuity equation above. These velocity and density variations require the existence of pressure gradients with the integrated effect being sufficient to provide load support. The pressure profile shown in the diagram will vary with load, axial position, bearing geometry, etc. Although the profile shown is not necessarily typical of all journal bearings, it is adequate for a qualitative discussion.

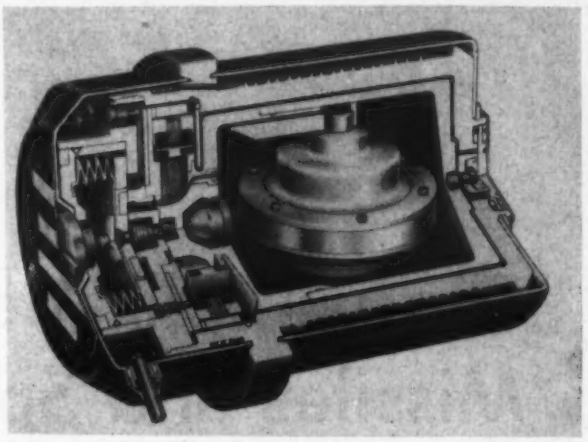


FIG. 3. **CUTAWAY VIEW** of gas bearing gyroscope shows spin-motor supported in a cylindrical gimbal supported by a viscous fluid to achieve near friction-free support.

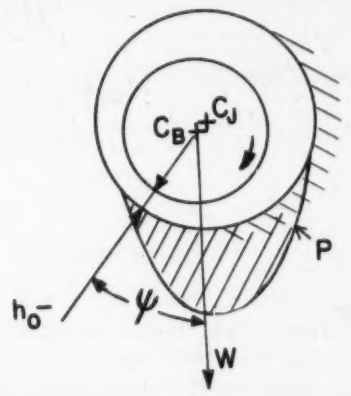


FIG. 4. **GAS BEARING** Principle depends on load-bearing strength of film of helium gas. Built up by shaft rotating in a concentric bearing shell. W is load on bearing; ψ is attitude angle; ho, minimum film thickness; P is pressure profile providing support.

Gyro Applications in Ballistic Missiles and Space Vehicles

By PAUL W. OTT,

Nortronics Div., Northrop Corporation

GYROSCOPES are used in ballistic missile and space applications as sensors for both guidance and control systems. They are used as angular position sensors in both systems and as angular rate sensors in control systems. The angular position gyros may be either of the single-degree-of-freedom integrating type or of the two-degree-of-freedom type, both of which have been used extensively in ballistic missile and space applications to date. Angular rate is measured with single-degree-of-freedom spring restrained instruments. The state-of-the-art of angular position gyroscopes has advanced considerably over the last decade resulting in the present day performance which has made inertial guidance for ICBM's feasible.

Missile Guidance System

A gyro stabilized inertial platform, containing in addition to the gyros three accelerometers, is the sensing element for an inertial guidance system. Since the gyros stabilize the platform in inertial space, the acceleration, velocity and position of the missile as calculated by the computer may be compared with a stored reference (Fig. 1). Any errors in the trajectory are corrected by applying the appropriate guidance signals to the control system.

The gyros used on the platform may be three single-degree-of-freedom integrating gyros or two two-degree-of-freedom gyros depending on the system being used. These gyros are quite different in construction and operating principles but both supply an angular position reference to inertial space.

The single-degree-of-freedom integrating gyros presently being used are an outgrowth of the work of Dr. C. S. Draper and his staff at M.I.T. Instruments of this type are widely used on present day intercontinental ballistic missiles. The fluid flotation technique used permits these gyros to perform well under the environmental conditions of vibration, acceleration, and shock experienced in the missile.

The two-degree-of-freedom gyros are of various configurations as developed by several different groups. The devices are gimbaled rotor structures with angular error sensors on the gimbals. A redundant axis results from the use of two of these units on a platform.

Presently under development are so-called strapdown guidance systems which do not have an inertial space referenced gimbaled platform, but consist of three single-degree-of-freedom gyros and three accelerometers mounted directly on the missile. Since the sensors are not stabilized in space, the computer must be capable of considerably more complex computations. In addition the gyros must have larger memory angles than when used on platforms since the missile response to perturbations is much slower than the gimbaled platform's response and, therefore, error angles of several degrees may result before proper correction is made. This requirement has resulted in the development of very low drift gyros with memory angles of ±5 degrees or more (Fig. 2). This gyro application is similar to that of the control system application to be discussed below except that the required drift performance is much more stringent.

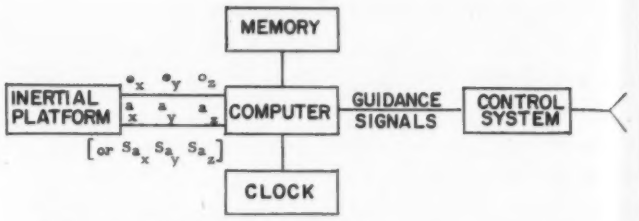


FIG. 1. MISSILE GUIDANCE system using three single-degree-of-freedom gyros and three accelerometers on a gimbaled inertial platform provide error angle and acceleration data to a computer where they are compared to a stored reference. Guidance signals resulting cause the control system to actuate guidance rockets, etc.

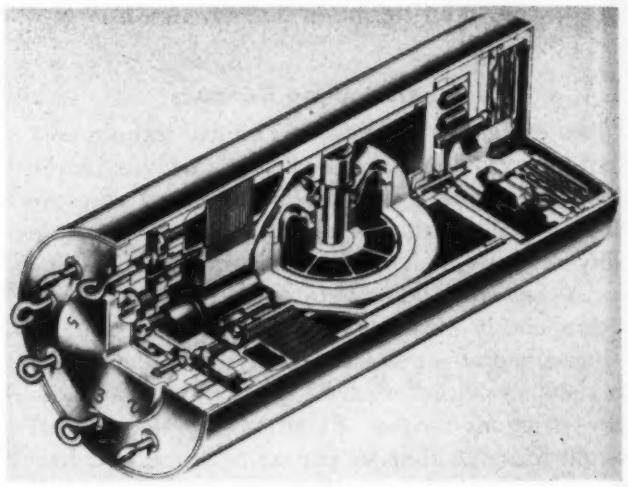


FIG. 2. SINGLE-DEGREE-OF-FREEDOM Gyro is sectioned to show construction. Present gyros attain very low drift with memory angles of ±5° or more and are frequently used "strapped down" to missile instead of in a gimbaled platform.

Missile Control System

Since ballistic missiles are large non-rigid bodies which are aerodynamically unstable, a control system is required to stabilize them. The control system will detect and counteract the instabilities such as bending, fuel sloshing, displacement of center-of-pressure and center-of-gravity, winds, etc. The control system consists of angular position and angular rate sensors, appropriate amplifiers, and thrust control devices (Fig. 3).

Many of the control systems now being used have as position sensors three single-degree-of-freedom integrating gyros. These gyros must have memory angles of ±5° or more to accept the angular error perturbations. It is also necessary to program these gyros to the nominal trajectory with guidance corrections being supplied by the guidance system.

Angular rate information is required by the control system to provide a stable system. Mechanically restrained rate gyros are presently used for this

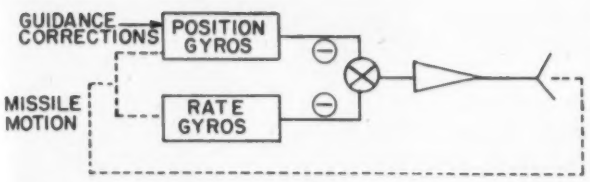


FIG. 3. CONTROL SYSTEM consists of angular position and angular rate sensors both acting to provide inputs to the amplifiers and thrust control devices.

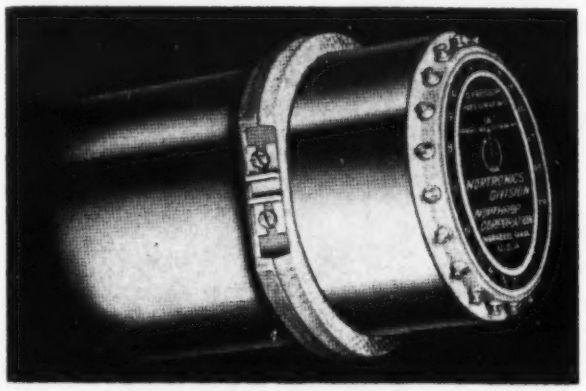


FIG. 4. SUBMINIATURE RATE GYRO with controlled damping is used at specific points on missile to measure missile motion.

purpose on most missile programs. These rate gyros are located at specific positions on the missile to make sure the gyros measure missile motion rather than local bending.

The performance requirements for the rate gyros are not too stringent except that their frequency response must be adequate to meet control system requirements. This usually means that their resonant frequency be well above the control system response frequency and that their damping be controlled to reasonable limits. From these considerations, as well as those of minimum size, weight and power, have evolved subminiature gyros with controlled damping requiring no heaters. Fig. 4 illustrates one such unit manufactured by the Precision Products Department of Nortronics.

For some control system applications such as the second stage Able vehicles, rate information is obtained by proper "shaping" of the angular position signal. This is possible only if the bending frequencies are relatively high and/or the position gyros are located so as to be free of bending mode rates.

Initial Control in Space Missions

The space vehicle usually consists of several stages of launch vehicle plus the final payload containing experimental equipment. The above discussion of ballistic missiles describes, in general, the launch vehicle.

Various sensors have been proposed for attitude

stabilized payload applications. Among these are sun sensors, earth seekers, moon seekers, star trackers and gyros. The limitation of gyros as sensors is that of gyro drift. Since most space missions (lunar or planetary) involve several days travel at the very least, even a small amount of drift is unacceptable. On the other hand, gyros are very desirable as control system sensors for detecting missile body rates. Therefore, for many applications, a system consisting of gyros as rate sensors for the control system and celestial body sensors for guidance will no doubt be used.

The necessity of the payload control system operating during the long period from launch to landing (or orbiting) presents some gyro considerations different from those of the ballistic missile application. Of special concern is gyro life expectancy and probability of proper operation during extended midcourse operating periods. The fact that the gyro is operating in a zero-G, essentially vibrationless environment for most of this time means that the gyro is operating under very nearly ideal conditions since such degradations as mass unbalance, mass unbalance shifts and anisoelastic coefficients are no longer of any concern.

Almost all of the thrust control devices proposed for space vehicles involve gas jets. Dual control systems consisting of on-off gas jets and some proportional control, such as servo-motor-flywheel systems, may be employed. The gas jets serve as a means of "dumping" the flywheel angular momentum when the full speed of the servo motor is reached. Proportional gas jets are now being developed to obviate the need for dual control systems. In either of these systems it is necessary to keep the body angular rates as low as possible to reduce the total gas consumption, and to do this it is necessary to detect extremely low angular rates. The single-degree-of-freedom integrating gyro used as an electrically restrained rate gyro is capable of detecting rates as low as a few degrees per hour.

Angular rate sensing is also required to reduce the perturbations which may occur at separation of the payload from the rest of the missile. These rates will probably be large enough so that they may be detected with spring-restrained rate gyros. This rate information would then be appropriately processed by the control system to reduce the perturbations to an acceptable level.

An interesting application of gyros for space missions is that of a second stage coast phase. With the advent of restartable engines (such as Able Star, Agenda B) it is necessary that the missile attitude be controlled during rather long coast periods. This means that the missile will probably exceed the normal radio guidance range before the engine is restarted and, therefore, the control system (or strap-down guidance system) gyros must control the attitude. To maximize the probability of the correct attitude for second stage restart, the gyro drift should be as small as possible. Therefore, normal control system gyros may be required to operate satisfactorily in a zero-G vibrationless environment as well as during powered flight.

Electronic Specialties Feature Teflon Characteristics

Subminiature Teflon® terminals, O-rings, mechanical limit stops and instrument clamps are among the items featured in a new 24-page pocket-size catalog by the Sterling Precision Corporation, Component Division, 5 Sintsink Drive East, Port Washington, L. I., N. Y.

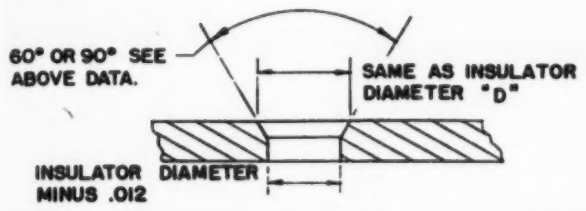


FIG. 1. PREPARATION of hole in chassis for insertion of TEFLON terminals is simple.

Specially developed 100% virgin Teflon with consistently low dielectric constant, low power factor over a frequency range from 60 cps to 30 mc, and low capacitance is used in a wide range of standoffs, feedthrus, jacks and plugs for HF, VHF, UHF, Microwave, radar and other high class electronic circuitry. These are installed permanently in 4 seconds, in metallic or non-metallic chassis, with a simple "corking" motion into punched or drilled holes.

Preparation of the hole for installation is simple. First the hole is drilled to the insulation body diameter "D" minus 0.012" (Fig. 1). When the material is over 0.040" thick, countersink the insertion side of the hole 60°. When the material is less than 0.040" thick, countersink with a 90° included angle countersink. Finally press the terminal into place. The resiliency of virgin Teflon seals and holds permanently without extra hardware—no nuts, washer, staking or soldering.

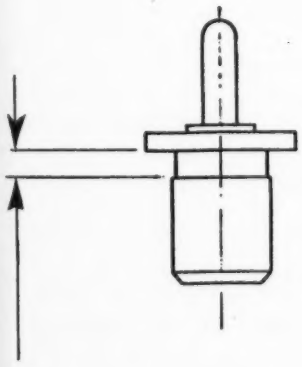


FIG. 2. INCREASED Pullout resistance can be provided to customer specification by groove "G" supplied to fit chassis thickness.

Insulators, terminals and jacks are available in a wide number of styles in white or eight RETMA colors which are applied to the insulation in such a manner as to leave the dielectric properties unchanged from those of natural Teflon. When increased mechanical bond and pullout resistance is considered advisable, special terminals will be furnished to customer specification with a groove in the Teflon bushing (Fig. 2). The customer must advise as to exact chassis thickness.

® Registered trademark of the Du Pont Co.

FOR THIS LITERATURE CIRCLE 99 ON READER-SERVICE CARD

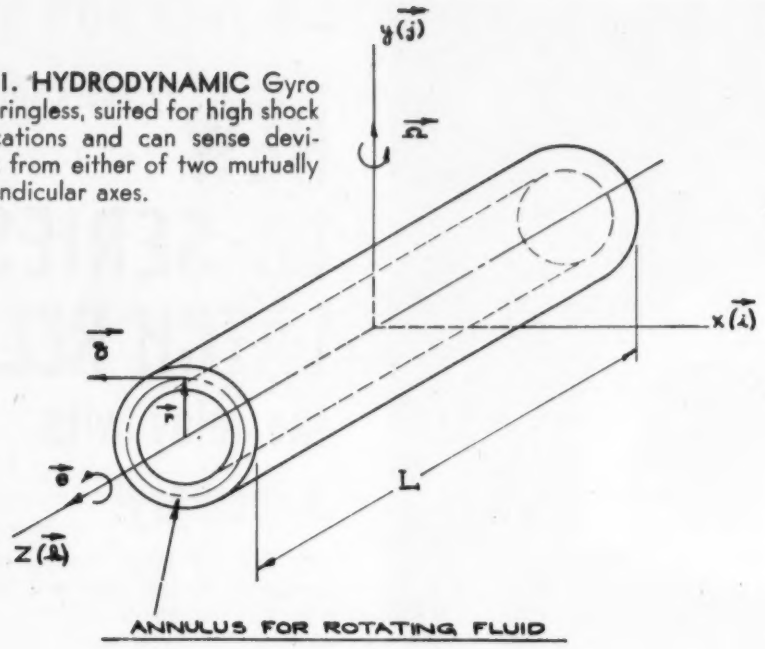


FIG. 1. HYDRODYNAMIC Gyro is bearingless, suited for high shock applications and can sense deviations from either of two mutually perpendicular axes.

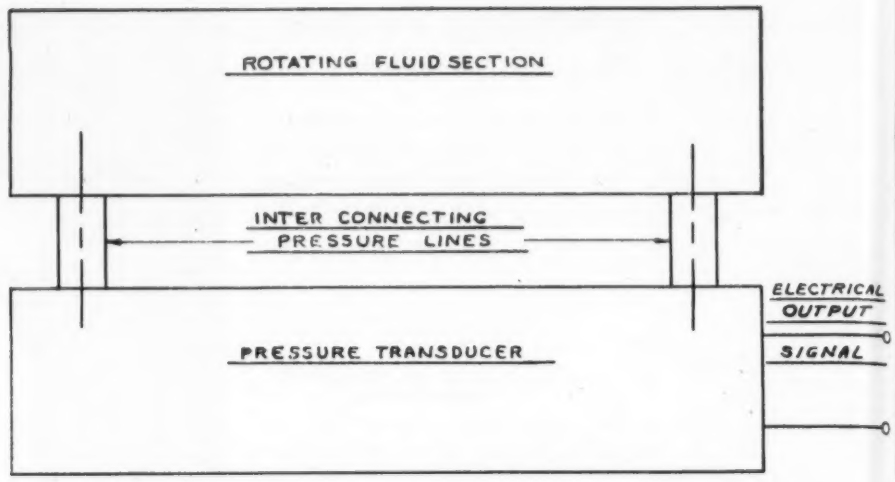


FIG. 2. TRANSDUCER SECTION is connected with pressure lines to rotate fluid section of hydrodynamic gyro.

The Magnetohydrodynamic Gyroscope

R. V. MONOPOLI, Industrial Division, Speidel Corporation, Providence, Rhode Island

THE MAGNETOHYDRODYNAMIC gyroscope is a device in which a conducting fluid, e. g. mercury, is driven by a rotating magnetic field around a closed annular path formed between the inner surface of a magnetic sleeve and the outer surface of a magnetic cylinder placed inside the sleeve and concentric with it. When the device experiences rotation about any axis other than the fluid spin axis, a Coriolis force acts on the spinning fluid creating a pressure gradient along the spin axis. The magnitude and direction of the pressure differential developed from one end of the fluid annulus to the other are functions of the magnitude and direction of the input angular velocity. A suitable transducer can sense this pressure signal and convert it to an electrical output signal.

The analysis of the operation of this type of gyroscope must be approached through principles which are different from those applicable to the common gyroscope.

Represented in Fig. 1 is a cylinder concentrically located inside a sleeve. Both cylinder and sleeve are made from a high permeability magnetic material. The space between them forms an annulus which is filled with mercury and closed at the ends with copper rings. These rings conduct current passing through the mercury and are the counterparts of the shorting rings in a squirrel cage induction motor. Each ring has a small pressure port at the upper half of the y, z plane.

Not indicated in the figure, but actually present, are longitudinal slots in the outer circumference of the cylinder containing copper wires wound in a manner standard for stator windings of a three phase induction motor. Three phase currents in these stator windings cause a rotating magnetic field to be directed radially across the annulus. The field induces eddy currents in the mercury. Interaction between the eddy currents and the rotating magnetic field causes the mercury to be driven in the annular path.

When the device experiences rotation about any axis other than the fluid spin axis, a Coriolis force acts on the spinning fluid creating a pressure gradient along the spin axis. Thus a pressure differential, p, is developed between the pressure ports at opposite ends of the fluid annulus which is given by the vector equation

$$p = 2\delta \vec{Lk} \cdot [\vec{\Omega} \times (\vec{\theta} \times \vec{r})] \qquad (1)$$

where δ is mercury density, $\vec{\theta}$ is the angular velocity of mercury, $\vec{q}$ its linear velocity where it passes the pressure ports, $\vec{r}$ the mean radius of the annulus, $\vec{\Omega}$ angular velocity of the device (here shown to be completely around the y axis), L its length, and $\vec{\theta} \times \vec{r} = \vec{q}$.

Because the linear velocity vector reverses direction each 180°, this same pressure differential is developed between two points at one end of the annulus separated by that amount. Therefore, an alternate location for the pressure ports is at the same end of the annulus, one in the upper half and one in the lower half of the y, z plane. For the case depicted in Fig. 1 where the orientation is such that all vectors are normal to each other, equa-

tion (1) reduces to the scalar equation

$$p = 2 \delta L \Omega q \qquad (2)$$

A unique advantage of this type gyroscope is that rotation about either of two mutually perpendicular axes can be sensed by a single unit. This is accomplished by having a second pair of pressure ports displaced 90° from the pair previously mentioned.

Conversion of the pressure signal to an electrical output signal can be accomplished using transducers such as the following (See Fig. 2):

1. Mercury cut-off switch-in which the tip of a metallic contact placed in mercury is either covered or uncovered by an insulating diaphragm actuated by the differential pressure, thereby opening or closing an electrical circuit.

2. Differential transformer-in which the differential pressure acting on a diaphragm or piston causes linear motion of a magnetic core within standard differential transformer windings.

The first of these transducers allows operation of the device as a rate switch which will actuate at some predetermined rate of turn. With a differential transformer type transducer, the device operates as a rate gyro, giving a continuous output signal with amplitude and phase proportional to rate and direction of turn respectively.

In both transducers the mercury in the annulus and in the transducer forms a closed fluid loop interrupted only by the diaphragm or piston. These moving elements are inertia compensated, i.e. the average density of the materials used in their construction is equal to the density of the mercury. The transducer is thus rendered insensitive to inertia forces.

Results from the development test program undertaken by the Industrial Division, Speidel Corporation, 88 Ship St., Providence 2, R. I., have demonstrated the practicality of a gyroscopic instrument based on the principles proposed by Dr. P. F. Malder of Brown University, holder of a patent on the device. The obvious advantages which this device has over the conventional gyro are:

1. Construction is greatly simplified since no bearings are required.
2. The rugged construction makes it well suited for operation under extreme conditions of shock and vibration.
3. Sensing can be accomplished about either of two mutually perpendicular axes with a single unit.

With input powers of less than five watts, the sensitivity is one degree per second when operated in the form of the simple rate switch previously described. Greater sensitivities result from the use of a higher input power in a larger device, in cases where space, weight, and power are not limiting factors. The damping and natural frequency are adjustable within limits.

FOR MORE INFORMATION CIRCLE 100 ON READER-SERVICE CARD

Energy Absorber Cushions Pilot in Barrier Crashes

CHAS. N. HOOD II, Director of Engineering,
Airborne Accessories Corporation, Hillside 5, New Jersey

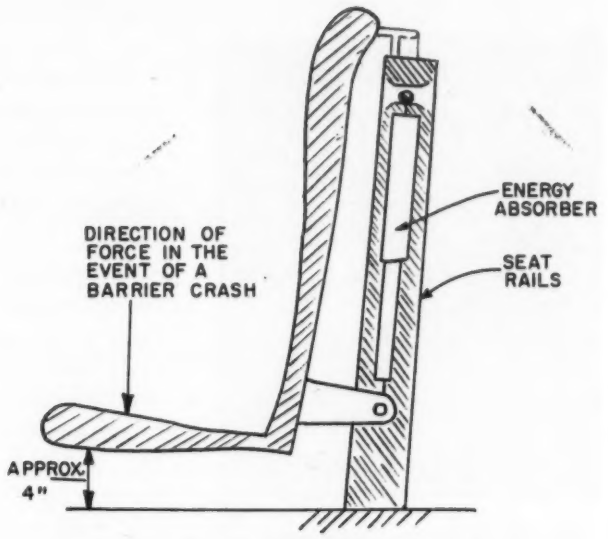
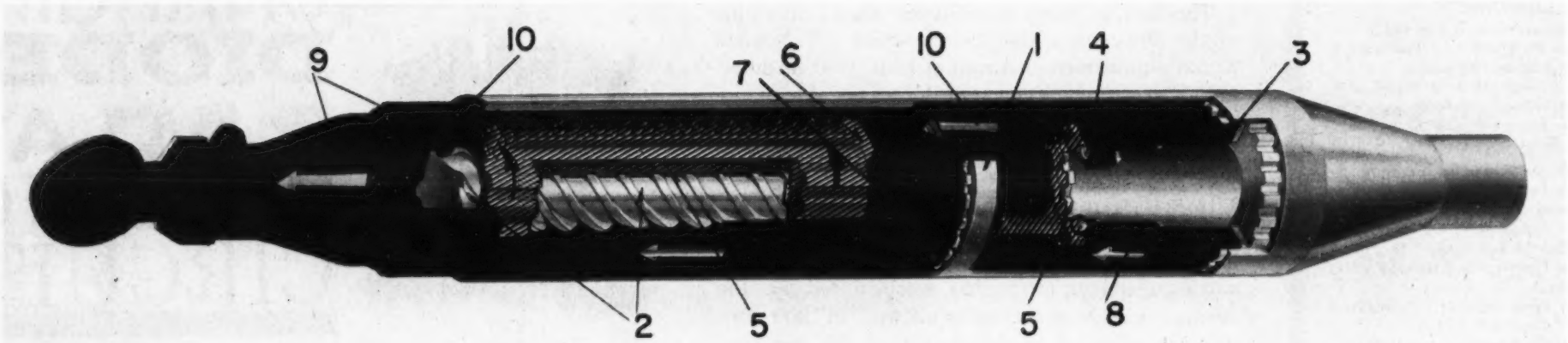


FIG. 1. NEW ABSORBER is Link in normal seat-adjusting Mechanism.



DESPITE modern angled-deck carrier designs, jet pilots are still occasionally injured when barrier crashes or hard landings occur. In barrier crashes a deceleration force of up to 30 G for approximately 0.033 second can develop, usually resulting in vertebrae injury. A load of 18 G, on the other hand, can be safely experienced when the pilot is positioned and secured in the typical aircraft seat.

This device, developed by Airborne Accessories Corporation, safely absorbs 12 G above the endurable shock limit of 18 G. The weight of the pilot, seat and personal flight equipment total just over 300 lbs, which must be decelerated by 5 G in only 5″ of cockpit space.

Naval Air criteria met are: Action of the device is relatively independent of environmental conditions; at loadings below 18 G, the device acts as a rigid member; it acts without rebound; is highly predictable in its action; it is re-useable, directly calibratable and testable. These criteria eliminated techniques dependent on crushing, elongation or shearing of material. Also, hydraulic mechanisms were considered unpredictable over the expected temperature range, as were several potentially interesting clutching arrangements involving powdered metals. The approach selected uses controlled friction clutches incorporating a provision for their calibration and adjustment. The device translates the linear impact motion into rotary motion for actuation of the clutch discs. The mechanism is a member of the normal power-operated seat-adjusting mechanism (Fig. 1).

The purpose of the *Energy Absorber* is to carry all tension loads up to 18 G without physical change. Any further load causes the unit to elongate, absorbing the excess energy and thus limiting the maximum force transmitted to the "protected" load.

The plain colored portions of Fig. 2. show the members which move axially under a tension exceeding 18 G. The cross-hatched colored members also rotate during elongation in addition to moving axially, and are driven by the worm threads on the inner surface of cylinder (5) and externally on part (2). Note that some of the clutch discs rotate with the cylinder because they are splined to its exterior, while alternate discs are kept from rotating by the inner splines in member No. 10. Friction between the two sets of discs dissipates the energy, raising the temperature approximately 15°F in a single operation in which the device absorbs 12 G under a 302-lb load.

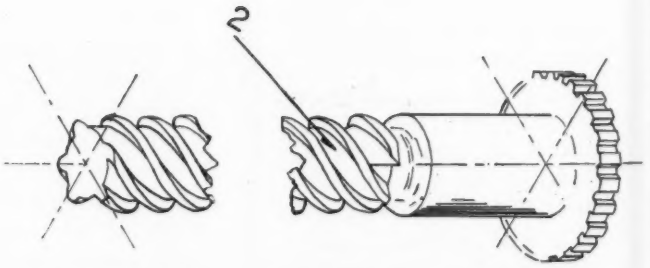


FIG. 2. ENERGY ABSORBER is independent of environmental conditions; operates only on forces exceeding safe deceleration.

Detailed Operation

The elegance of the design is shown by the manner in which a breakaway peak load is avoided. Actually if the applied load approaches an impact, a momentary negative peak occurs. Also, after use the device may be collapsed and reset for a second operation without disturbing its calibration.

Referring again to Fig. 2, the center member, No. 2, is helically splined externally but terminates in a flange with longitudinal splines. These splines mate with the internal longitudinal splines of the outer sleeve (1), which extend throughout its length. After assembly, part No. 2 is securely fastened in Part No. 1 so that it cannot turn or slide under tension.

No. 10 is a cylinder with external straight splines which slide easily into the internal splines of member No. 1. No. 10 also contains internal straight splines. One end of No. 10 is threaded internally to fit stop No. 3, which has external splines to fit internal splines in No. 1. These prevent rotation of No. 3, but permit free axial translation of No. 3.

No. 3 bears against a spring pack No. 8 consisting of a number of Belleville disc springs. Following the spring pack is a thrust bearing No. 4, which transmits its thrust to a friction pack consisting of alternately stacked outer discs (7) and inner discs (6). The outer discs are externally splined to mate with member No. 10, while the inner discs are internally splined to mate with external splines on part No. 5.

Part No. 5 has internal helical splines that mate with the external helical splines of part No. 2, while the right end of No. 5 rests against thrust bearing No. 4. The friction pack, thrust bearing and disc spring pack are held under compression by the pressure adjusting nut No. 9 which screws into internal threads in the end of part No. 10.

At rest, the pressure of spring pack (8) forces discs (6) and (7) of the friction pack together, preventing rotation of the assembly. The maximum force necessary to overcome this friction is determined by the setting of the pressure adjusting screw No. 9.

Applying an impact tension load in excess of this maximum value through parts (9), (10) and (3) compresses the spring pack (8) and forces the thrust bearing (4) against the splined cylinder, No. 5. This momentarily relieves some of the pressure on the friction discs, providing a momentary "negative peak" during breakaway. The disc pressure and full friction loading is quickly restored as part No. 5 rotates with a rotary screw motion toward the left end of part No. 2. Friction between the discs retards this rotary motion and converts the thrust energy into heat.

Once elongated, the device is removed from the seat adjusting linkage, the lock between members 1 and 2 disengaged, part No. 1 slipped off the inner assembly and part 2 is screwed back into its retracted position in sleeve No. 5. The inner assembly is then inserted into sleeve No. 1, and members 1 and 2 re-locked together. This returns the device to its ready state, no change in the spring loading adjustment being necessary.

During tests of aircraft barrier crashes when the pilot seat is equipped with the shock absorber, the aircraft has been found to travel 6.3″ after the impact. The pilot in his absorber equipped seat moves 10.5″, with the absorber extending 4.2″. This lengthens the man's period of deceleration from the .033 seconds in which the aircraft is arrested to .055 seconds, and reduces his peak deceleration from 30 G to a safe 18 G.

Other possible uses of the new absorber principle may include automobile safety belt arresters, and landing gear shock absorbers. The Energy Absorption Device was designed by Louis Fuchs, Senior Development Engineer, and is the subject matter of a pending patent application assigned to Airborne Accessories Corporation, 1414 Chestnut Ave., Hillside 5, New Jersey.

FOR MORE INFORMATION CIRCLE 101 ON READER-SERVICE CARD

Gimbal Angle Transducers Require Increased Accuracy and Speed

Missile stable platform pickoffs, operating to ever higher limits of precision and speed, are demanding more thoughtful consideration from the designers of guidance system transducers. Single and dual-speed synchro and resolver pickoffs are giving way to Inductosyn[1] and optical encoder techniques utilizing standard and pancake configurations for those applications requiring the highest precision. Both the Inductosyn and optical techniques are available in coaxial pancake configurations—permitting straightforward adaptions to presently available gimbal systems—in precision devices now being produced by the Dychro Corporation, Wellesley 81, Mass.

For analog systems and particularly those that must be compatible with two-speed pickoff systems, the Inductosyn is unsurpassed for ruggedness and simplicity of application. For digital pickoff requirements, direct encoding is available with accuracies to one minute of arc in systems allowing a 3″ to 5″ diameter instrument. The system shown in Fig. 1 combines these two techniques to provide both analog and digital information with great resolution and accuracy, Both optical encoding and Inductosyn techniques can be used in the accuracy range from a few seconds of arc to a tenth of a degree or more; realization of these accuracies being dependent upon dynamic performance requirements and other parameters.

The system (Fig. 1) uses a resolver as a coarse pickoff and an Inductosyn co-axial arrangement as a fine pickoff for a single gimbal axis. The Inductosyn output is equivalent to that of a resolver geared up N times where N may be any value between 50 and 250. These outputs operate servo repeater positioned shafts so that the information may be distributed in analog and digital form as required. These repeaters are generally designed so as to be especially compact and reliable. The accuracy of this system is dependent upon the size of the pickoff Inductosyn and the dynamic performance required in the servo repeater.

When a digital readout is required in the simplest and most direct manner, an optical encoder is mounted directly on the gimbal. Fig. 2 shows the principles of operation of such an encoder. Strobotron lamp illumination sources are commonly employed in military applications of optical encoders because they permit very high light levels and a pulsed signal system. A number of output configurations are available to reduce the number of slip rings required.

FOR MORE INFORMATION CIRCLE 102 ON READER-SERVICE CARD

[1] Inductosyn is the registered trademark of Farrand Controls, Inc., New York 70, N. Y.

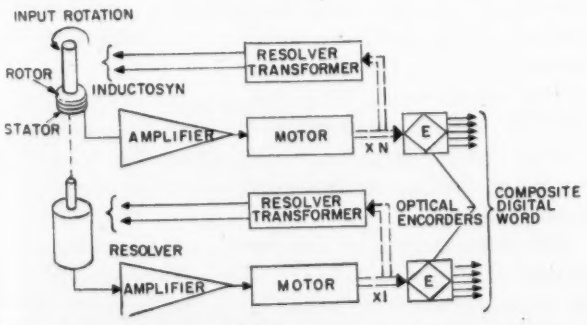


FIG. 1. ANALOG-DIGITAL Transducer System is provided by combination of Inductosyn and optical encoders.

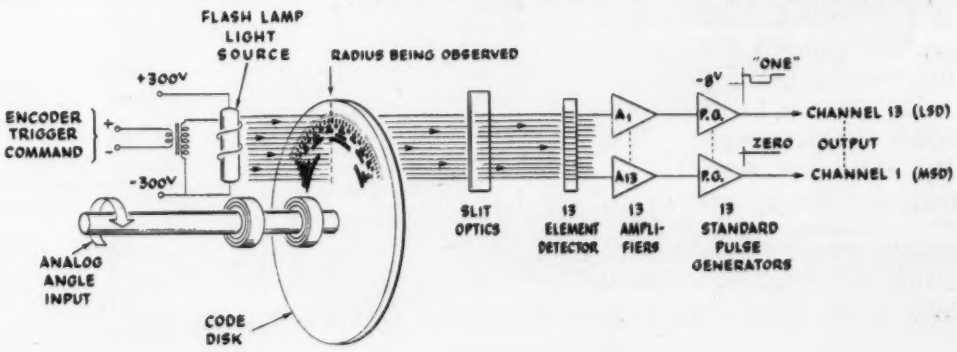


FIG. 2. OPTICAL ENCODER with strobotron lamp illumination provides pulsed coded outputs with accuracies to one minute of arc in 3" to 5" diameter instruments.

Electronic Circuitry

A continuing MILITARY SYSTEMS DESIGN feature, these circuits are selected because they represent good design. Significant characteristics which are not self-evident from the diagram are explained in the printed commentary.

TRANSISTORIZED-SCOPE DEFLECTION AMPLIFIER

A 2-v sweep from the trigger and sweep generator circuit is direct-coupled into the horizontal-deflection amplifier (Fig. 1) to maintain a high amplitude stability. This is first fed into Q21, an emitter follower, and is attenuated through resistor R76 and mixed with the positioning voltage from R72. With the degeneration due to the emitter resistor (R60) in Q15, the voltage gain of the string of PNP transistors (Q15, Q17 and Q19) is approximately 100. This signal is connected to the first horizontal-deflection plate (Terminal 5). A small amount of this sweep voltage is picked off across R74 and coupled into Q20, where it is amplified by the NPN string of Q16, Q18 and Q20. This string has a voltage gain of about 30 and provides the opposite-phase signal to the other horizontal-deflection plate of the CRT. (Terminal 4).

The biasing for the PNP string of transistors can be arranged to give equal voltage drops at any given d-c output with the resistors, R64, R67, R70 and R74 (top). However, using only these resistors, sufficient drive to the bases cannot be obtained when the transistors are near full conduction. R66 andl R73 (top) provide this increased base current for Q17 and Q19 when the string is in full conduction. The same arrangement is used for the NPN string.

In a triggered type of sweep, the period between sweeps is longer than the duration of the sweep. It is, therefore, permissible to use a deflection amplifier having good response during the forward trace time and reduced performance during retrace time. This is accomplished in the model 150 by utilizing the complementary characteristics of P-N-P and N-P-N transistors. The P-N-P string, Q15, Q17 and Q19 is driven into higher conduction during the forward trace time and produces the positive-going deflection waveform. The complementary N-P-N string produces the negative going deflection waveform.

The effective bandwidth of either amplifier string is determined primarily by the deflection plate and stray capacities combined with the driving impedance of the amplifier string. Since the driving impedance of each string is 50K shunted by the impedance of the transistor string during the forward trace and the full 50K during retrace, the forward trace bandwidth is significantly higher than the retrace bandwidth. Bandwidth is further enhanced by the small high frequency by-pass capacitors C24 and C25. One of the benefits gained by this technique is the reduced power supply drain derived from the use of the 51K load resistors.

Display: 1" CRT (NU P-122P1) with 6 div by 10 div graticule.

Sweep range: 5 calibrated steps—1 μsec/div, 10 μsec/div, 100 μsec/div, 1000 μsec/div, 10,000 μsec/div.

Triggering: Synchronized from plus or minus slope or free-runing. Signal amplitude of ½ div or more will provide stable sweep. Trigger point is continuously adjustable from any point of the display on either positive or negative slope.

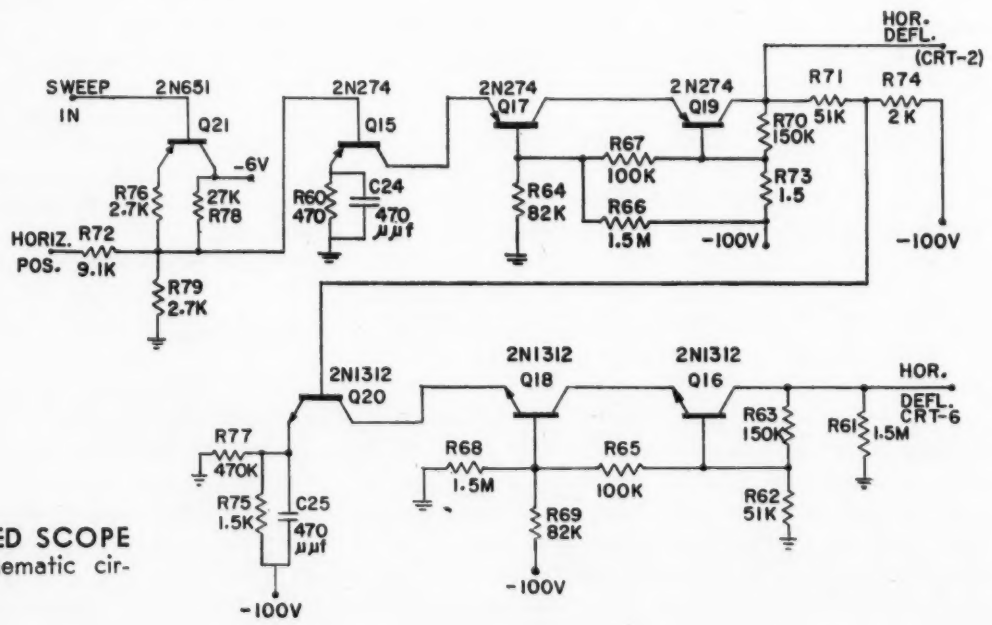


FIG. 1. TRANSISTORIZED SCOPE Deflection Amplifier schematic circuit.

TRANSISTORIZED-SCOPE POWER SUPPLY

The source power for a small oscilloscope[1] can be an external nominal 6-v source or an internal 6-v rechargeable battery. The 6-v supply feeds a conventional square-wave dc-to-dc converter that has 3 output windings. One of the output windings (8-7-9), is a 16-v center-tapped winding. It is connected to two full-wave rectifying circuits and provides ±8-volt output (Fig. 2.).

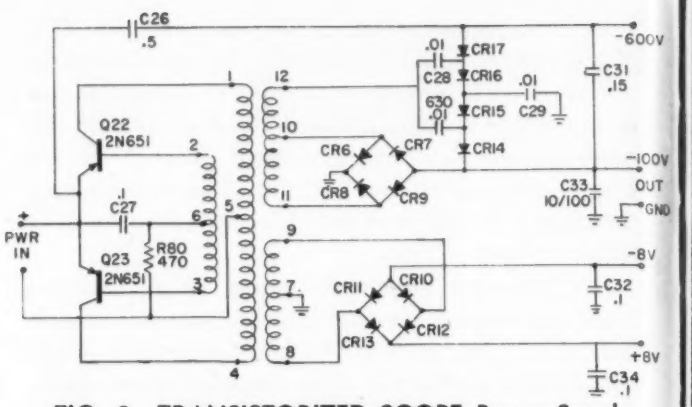


FIG. 2. TRANSISTORIZED SCOPE Power Supply schematic circuit.

The second output winding (10-11) is a 100-v winding, full-wave rectified to give —100 volts to the deflection amplifier.

The third output winding is also a 100-v winding (10-12) connected to one terminal of the first 100-v winding. The fact that the first 100-v winding is feeding a full-wave bridge rectifier gives a 200-v peak-to-peak square wave on the otuput end of the second 100-v winding, which is fed into a half-wave voltage-doubler circuit (CR14, CR15, CR16 and CR17) to provide a theoretical output of —700 volts. The actual output voltage (after losses in the coupling capacitors and due to loading effects) is a nominal —600 volts.

Source: EI Labs Div. of Electro Instruments, Inc., 1165 Morena Blvd., San Diego 10, Calif.

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[1]*Note*: The Deflection Amplifier and Power Supply circuits given above are components of the Electro Instruments Model 150 Transistorized Oscilloscope further described on page 48 of this issue. For more information on this instrument circle 103 on reader service card.

DIRECT-COUPLED AMPLIFIER FOR HIGH VOLTAGES

Where large voltage swings are required in excess of the maximum collector voltage rating of transistors available, the circuit shown in Fig. 3 may be used. In this circuit, the arrangement of Q_1, Q_2, Q_3 and Q_4 permits the use of a —100 v supply for V_{cc} which is divided among the resistors so that the collector voltage of each transistor is within the rated value of —30v for each Type 2N384 transistor. Since a single transistor does not permit a voltage swing in excess of its rated maximum collector voltage, the high instantaneous output voltage across R_1 must be shared at all times by the transistors connected in series. The transistors do not require matching for identical characteristics, and any number, in addition to the input transistor, may be used.

The voltage swing for each transistor appears across the 18K resistor connected in its base circuit, and the overall voltage swing appearing across the load resistor R_L is the sum of the voltage swings of the individual stages.

The current gain of the overall circuit is the same as that of the input stage Q_1, where the connection can be either grounded-base or grounded-emitter. When large current gains are desired, the grounded emitter connection, as shown, should be used.

Data for the 2N384 transistor are as follows: It is a

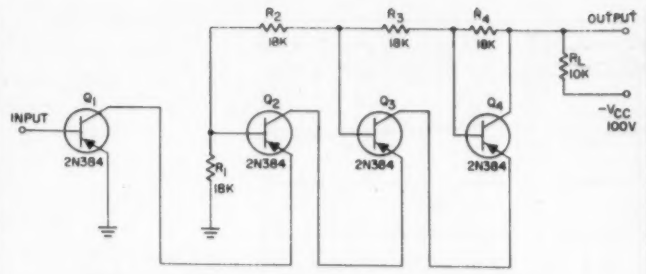


FIG. 3. HIGH VOLTAGE d-c amplifier.

PNP germanium drift type transistor with 120 mw max dissipation at 25°C, having a V_{ce} of 40 v max, h_{fe} of 60, maximum cutoff frequency of 100 kc, and I_{cbo} of 12 amp at 25°C.

Source: Contributed by J. B. Angell, Philco Corp., Circuit 2-7 in Selected Semiconductor Circuits, Navships 93484, Government Printing Office, Washington, D. C.

TWO-METER POWER SUPPLY

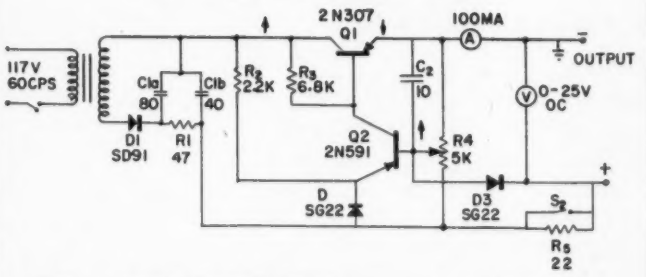


FIG. 4. POWER SUPPLY has guard circuit to protect transistors from shorted output. Output voltage is adjustable from 0 to 20v. D1 is Silicon rectifier, DC and D3 are Stabistor (Transitron) reference diodes. Arrows indicate voltage-change phase.

The power supply for breadboard transistor circuits or experimental work shown in Fig. 4 features regulated output and a guard circuit to prevent damage to power supply components in the event of a shorted output.

A 117/24v transformer provides isolation of the power supply from commercial power lines, and the half-wave output of diode D1 is filtered by the network R1 C1. Transistor Q1 operates as a series voltage regulator with its base potential determined by the collector voltage on control transistor Q2. Potentiometer R4 is the output voltage control.

Q2 acts as a common emitter amplifier with its emitter-base potential stabilized by diode D2. Any sudden surge in line voltage or decrease in load causing an increase in the potential across R4 will result in an increase in the base-emitter voltage; this signal will be amplified by Q2 but with a phase reversal, which means that there will be a decrease in the Q2 collector potential. Q1 is acting as a common-collector amplifier, which makes it act much the same as a cathode follower. This means that its output voltage waveform will have the same phase as the input signal waveform, but that it will have negative voltage amplification. The decrease in potential applied to the base of Q1 is then transmitted to the Q1 emitter as a decrease in output potential.

ELECTRONIC CIRCUITRY

Continued from page 17.

Regulation of the circuit, using a 2N307 transistor as Q1, is shown in Fig. 5. For greater voltage stability, a higher gain 2N176 can be used instead. Voltage stability of the circuit is a function of the product of the gains of both transistors.

The guard circuit R5 and D3, limits the output current whenever an overload occurs. If the output terminals are shorted across, output voltage builds up across R5 and at 1.7 volts D3 conducts, removing the forward base-emitter bias on Q2 and reducing the emitter collector current. This in turn removes the forward bias from Q1, cutting its output to the minimum. At the same time, C2 is harmlessly discharged through D3.

Input: 110-125v 60 cps.

Output: 1-20 v dc, 100 ma.

Maximum load current 100 ma.

Regulation: 100 ma increase in load current produces less than 2 v change in output voltage.

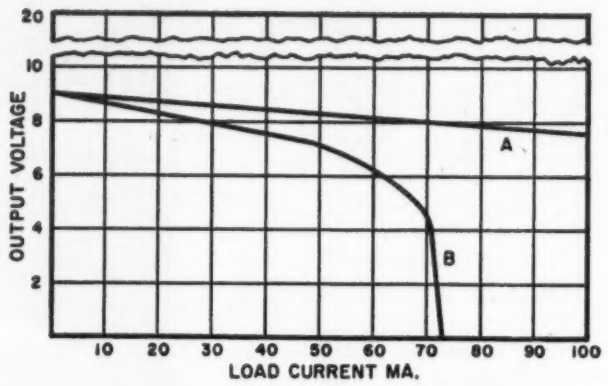


FIG. 5. REGULATION Characteristic, (A) Guard Circuit out, (B) Guard Circuit in.

Output impedance: With Guard Circuit out, 20 ohms.

Source: "Dual Meter Power Supply" *Popular Electronics*, November 1960.

TRANSISTOR CIRCUITS—CURRENT FLOW AND VOLTAGE PHASE RELATIONS

(Second article in a continuing MSD Series)

In the following NPN circuits (Fig. 1), electron current flow is indicated by the direction of the arrows, with the flow of the minority carriers being ignored to simplify the circuit explanation. In this discussion it is assumed that with normal bias and no signal input, 95% of the emitter current reaches the collector, and 5% flows to the base. In each case if the NPN transistor were replaced by a PNP transistor, the polarity of the batteries and the direction of electron flow would be reversed, however, the voltage phase relationship would be the same.

CB Amplifier. The wave form at the left of Fig. 1-a represents the input signal wave. Consider an instant B at which the polarity AB *opposes* the forward bias of the base emitter battery. The forward bias is thereby reduced, reducing the total current I flowing through the emitter. The collector and base currents are correspondingly reduced, and the voltage drop in R_1 is also reduced. This causes the output voltage (to the right of coupling capacitor C) to rise accordingly. By similar action, when the forward emitter-base bias is increased, the emitter-collector current rises, causing a larger voltage drop through R_1, and causing the output voltage CD to swing negative. The output signal is in phase with the input signal in a CB amplifier.

CE Amplifier. The response of the Common Emitter circuit to a similar input signal is shown in Fig. 1-b. Here a positive swing in bias *aids* the emitter-base bias, increasing the emitter-collector current, increasing the voltage drop through the load resistor, and causing a negative excursion of the output voltage. In similar fashion, a negative input signal swing diminishes the emitter-collector current and causes a positive swing in the output voltage. In short, the output of the CE amplifier is 180° out of phase with the input.

CC Amplifier. The response of the Common Collector circuit is shown in Fig. 1-c. Here an increase in positive signal polarity aids the emitter-base bias, increasing the emitter-collector current. This causes a larger voltage drop across the load resistor R_1, which in this case means that the emitter output lead becomes more positive. As the input voltage swings negative, the emitter-collector current diminishes, causing the voltage drop through R_1 to diminish, which swings the output lead more negative. The result is that the output wave is in phase with the input signal; however, since the voltage of the collector battery is divided between the emitter-collector resistance and R1, the output voltage amplitude is always less than that of the input signal.

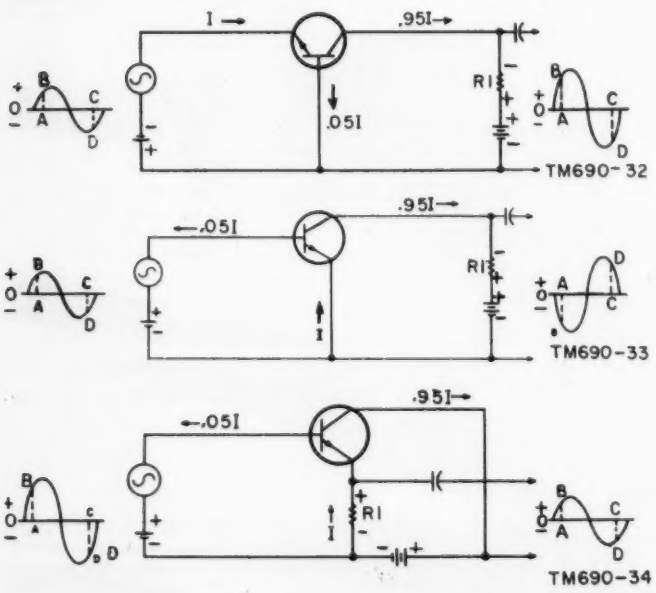


FIG. 1. ELECTRON current—voltage phase relationships in NPN circuits.

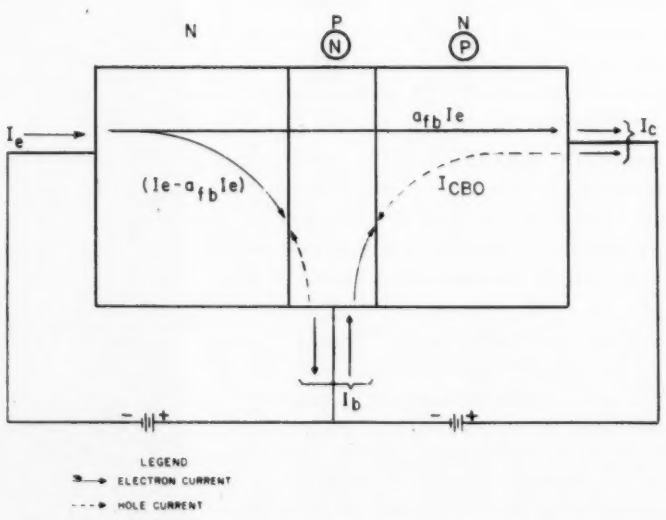


FIG. 2. BASE LEAD current direction and magnitude depends on relative strength of reverse bias current.

Effect of Reverse Current

In Fig. 1, the reverse current flow between the base and the collector was neglected. In an actual case, the direction of electron current flow in the base region depends on the percentage of emitter current that flows from the base lead and the magnitude of the reverse bias collector-base current that enters the base lead. In Fig. 2 an NPN transistor is shown with normal biases applied. To the minority carrier electrons in the base region, the base region acts as N-type material, as indicated by the circled *N*. To the minority carriers (holes) in the collector region, the collector region acts as P-type material.

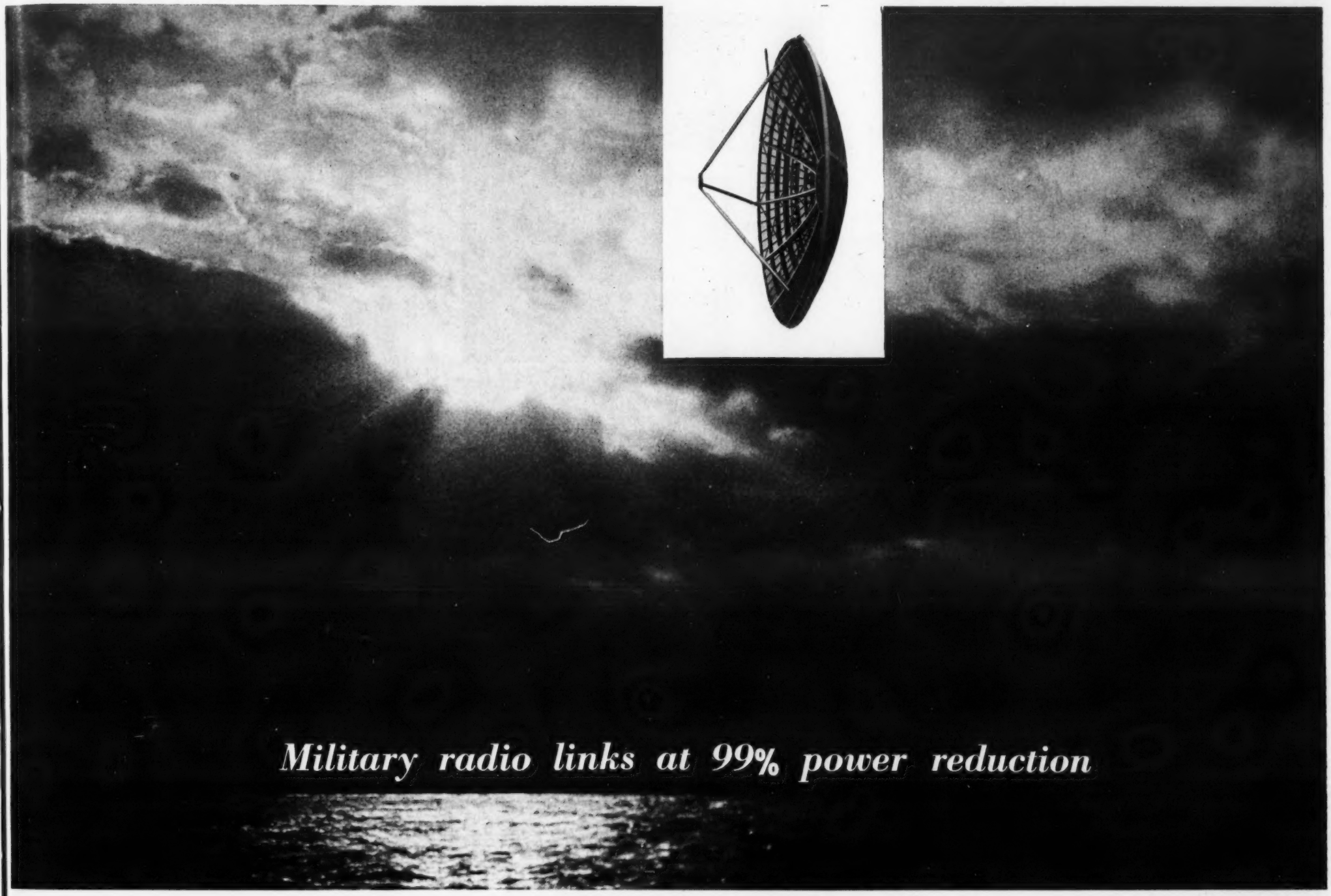
The emitter current I_e consists of electrons. Assuming the *current gain* of the common base amplifier is designated by the symbol α_{fb} (and defined as the ratio I_c/I_e in the *f*orward biased common *b*ase amplifer), the collector current will be $\alpha_{fb}I_e$, which will account for 92% to 99% of the emitter electrons. From 1% to 8% of the emitter electrons ($I_e - \alpha_{fb}I_e$) combine with holes in the base region, generated near the base lead. Generation of the holes causes an electron current to flow in the base lead *away* from the base.

In addition, reverse-bias collector current, I_{cbo} flows between *b*ase and *c*ollector. I_{cbo} consists of a flow of electrons in the base region that combine with holes from the collector region at the base collector junction. The reverse bias current causes a flow of electrons in the base lead and *toward the base.*

The direction of the resultant electron flow will be seen to depend on the relative magnitudes of ($I_e - \alpha_{fb}I_e$) and I_{cbo}. If $I_e = 1$ ma; $I_{cbo} = 0.01$ ma; and $\alpha_{fb} = 0.92$, the resultant base lead current would be 0.07 ma flowing *away* from the base. If $I_{cbo} = 0.02$ ma, and $\alpha_{fb} = 0.99$, the base lead current will be 0.01 ma, flowing *toward* the base.

In a PNP transistor, the roles of the internal electron and hole currents, also the bias potentials and directions of electron flow externally, are reversed. (Some hybrid parameters of the common emitter transistor circuit will be developed in the Circuitry Section of the January-February 1961 issue).

[1]*Note.* Material in this series is adapted in part from U. S. Army Technical Manual TM 11-690.



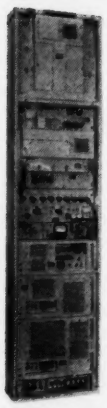
Military radio links at 99% power reduction

The United States Air Force has picked NEC's High Sensitivity Reception System to provide over-the-horizon radio links for radar sites on the three main islands of Japan.

The 17-station system contains no active repeater stations. Longest hop is 145 miles at 100 W output. Guaranteed reliability is a character error of no more than 1 : 10,000 for 99.9% of a year's hours.

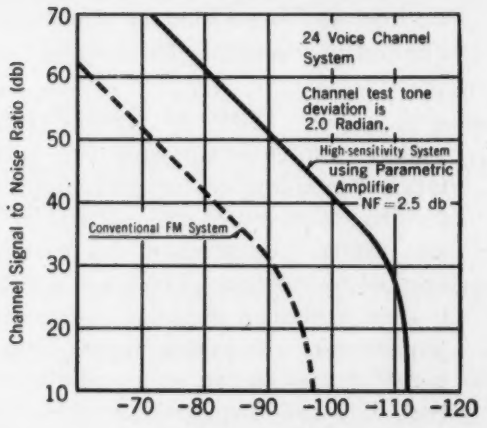
The NEC system combines high sensitivity reception, parametric amplifier, low feeder loss design, and the high antenna gain possible at 2000 mc. to improve S/N ratio by more than 20 db. This permits hops at 1/100 of the power required for conventional links.

The OH-2000 is drastically reducing installation and maintenance costs of over-the-horizon links in capacities up to 60 voice channels. A descriptive brochure is available on request.



OH-2000

With quadruple diversity, this compact 100 W transmitter requires a radio room of only 100 sq. ft. Final stage uses economical planar tubes. NEC also supplies completely transistorized carrier equipment.



NEC Components / Systems

Nippon Electric Company Ltd.

Tokyo, Japan

CIRCLE 19 ON READER-SERVICE CARD

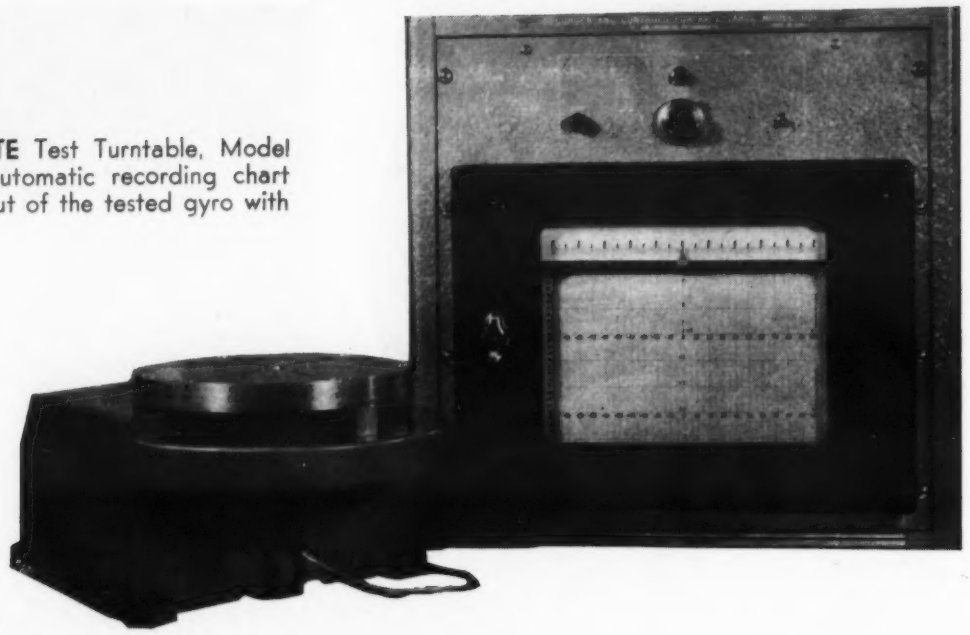


FIG. 1. VARIABLE RATE Test Turntable, Model 031, is provided with automatic recording chart which records error output of the tested gyro with known input.

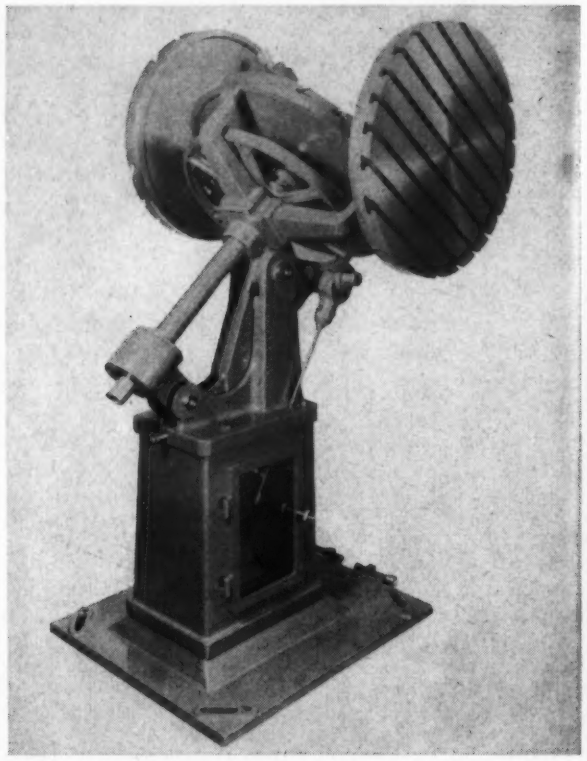


FIG. 2. SIDEREAL TEST Turntable, Model 063, when adjusted for the correct latitude and driven at sidereal speed, points the gyro axis continually at a fixed point in space. Any variation in gyro output is therefore due to drift.

Gyro Test Tables

PAUL KAESTNER, **Chief Engineer, J. W. Fecker, Inc., Pittsburgh 6, Pa.**

PRECISION TESTS on Gyros and Inertial Element systems are subject to the usual precision testing requirement that the response of the tested element to a precisely known stimulus must be accurately measured. However, in the case of gyroscopic devices, the rotation of the earth, which has a different component for each position of latitude, is an important part of the stimulus. Gyro testing tables must therefore either accurately compensate for the earth's rotation or effectively take it into account in evaluating the response of the gyro.

Types of Gyro Tests

Gyro testing equipments fall into two general types, depending on the philosophy governing the test. In one method a very accurately known regular rate input (compensated for earth's rotation) is applied to the gyro. The error output of the gyro is then plotted or recorded automatically for comparison with the known input. (Fig. 1). The test instrument is known as a variable *rate table*, and both rate and displacement gyros may be tested. Several gyros may simultaneously be tested on a single rate table if the error output from each gyro is used to drive a separate recorder.

In the second type of test, the gyro is used in a closed-loop system, with the table acting in its normal function as a null-seeking device. In this case, the gyro responds to the earth's rotation by sending an error signal to the torque servo of the test table on which the gyro is mounted. Its accuracy should ideally keep the servo table axis aligned on a fixed star. A step function test is also possible with the servo table. This determines how quickly the gyro or system settles down to a steady state after a severe disorientation.

Rate Tester Tables

Rate tables employ precision drives and, where the accuracy demands, frequency-regulated power supplies for their synchronous drive motors. Various types of variable speed drives may also be employed to permit operation of the rate tables over a continuous range of rates through zero speed. These include mechanical variable-speed control devices as well as rate speed controls. In use, the rate tables provide a known input to the gyro under test and the gyro performance is evaluated by measuring its response to the rate.

One type of variable rate test turntable provides a synchronous motor combined with a servo motor drive through a mechanical differential to produce continuously variable speeds through zero and to maximum speed in the reverse direction. Temperature compensation in the servo motor feedback tachometer may be used to improve accuracy. Where the desired rates are not too high, a worm gear mesh is usually employed for the final table drive gear mesh. This type of gearing provides smoother rates, less subject to the high-frequency tooth-profile rate errors which are found in spur gear drives. At higher rates, above 750°/minute, worm gear surface speeds become excessive and other types of drives must be used.

A special configuration of the rate table is the sidereal rate table (Fig. 2). This unit provides a position output within 5 seconds of arc of its theoretical position with respect to the fixed stars, throughout its rotation. The axis of rotation of the test platform is set parallel to the earth's axis by either precision surveying techniques or by direct astronomical observation using a special telescope. The table is driven by a synchronous motor from a crystal-controlled frequency source at sidereal speed and multiples thereof. The sidereal day is almost 4 minutes shorter than the solar day, due to the earth's motion about the sun.

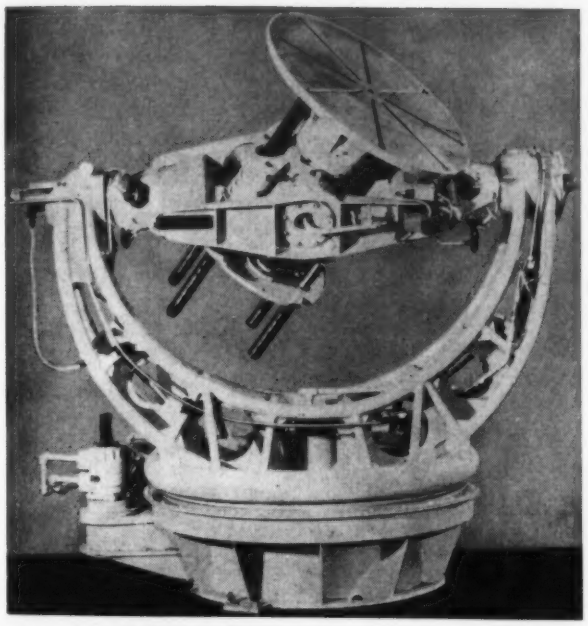


FIG. 3. THREE AXIS Scorsby Flight Simulator is hydraulically-driven unit for testing stable-element units weighing up to 200 lbs.

Rate tables are frequently mounted on yokes for tilting in one plane or on gimbals and yokes for tilting in two planes. The tilting means may be manually operated to provide the desired angles and may be provided with precision optical read outs for accurately determining the angles. In other cases, the tilt operation only requires a capability for restoring the equipment to its original orientation at the conclusion of the test. One of the angles of extreme interest for gyro testing is that which corresponds to the latitude of the test site. This allows the gyro to be completely isolated from the effects of precession caused by the earth's rotation.

Two- and three-axis tables are frequently power driven in all axes, generally through limited ranges. These drives may provide harmonic motions with continuous rotation available on one axis. Since these multiple axis tables are usually servo driven to follow some form of program they are readily adaptable as flight simulators to follow any program within their performance ranges. A hydraulically driven unit of this type is the 3-axis Scorsby Flight simulator (Fig. 3), which can test stable-element units weighing up to 200 lbs. Test turntables employing servo drives on a single tiltable axis are also widely used.

Servo Test Tables

One type of servo table (Fig. 4) is driven by a dc torquer mounted directly on the table drive shaft to eliminate the gearing usually associated with servo drives. The table may be used in a slave mode with the gyro under test mounted on the turntable surface with its input axis parallel to the

table axis. The table then rotates to reduce the error signal produced by the gyro. An optical electronic readout is provided which provides a pulse with each 6 minutes of arc table travel. With the addition of auxiliary timing, amplifiers, counters and printer, it is possible to print the elapsed time between consecutive pulses. In this mode of operation with the table set at the sidereal or latitude angle at the test site, a perfect gyro would drive the table at sidereal rate. Any departure from this condition would represent gyro errors. At other angles the component of the earth's rate will differ

FIG. 4. MULTIMODE TEST TURNTABLE, Model 052, has DC Torquer mounted directly on drive shaft. If set accurately for the sidereal angle at the test site, a perfect gyro will drive the table at sidereal rate, with any departure from this condition representing gyro errors.

from the sidereal rate by amounts which depend on the actual angles involved.

The servo table shown in Fig. 4 is also provided with a microsyn, the stator of which is rotated with the turntable shaft. Its rotor is driven by an accurate synchronous motor drive which provides one or more rates. The microsyn output may be used to provide the error signal to the torquer motor. In this mode of operation, the unit is actually used as a rate table although it is not quite as accurate as the direct drive rate tables. To provide greater accuracy for rate operation, special direct gear at-

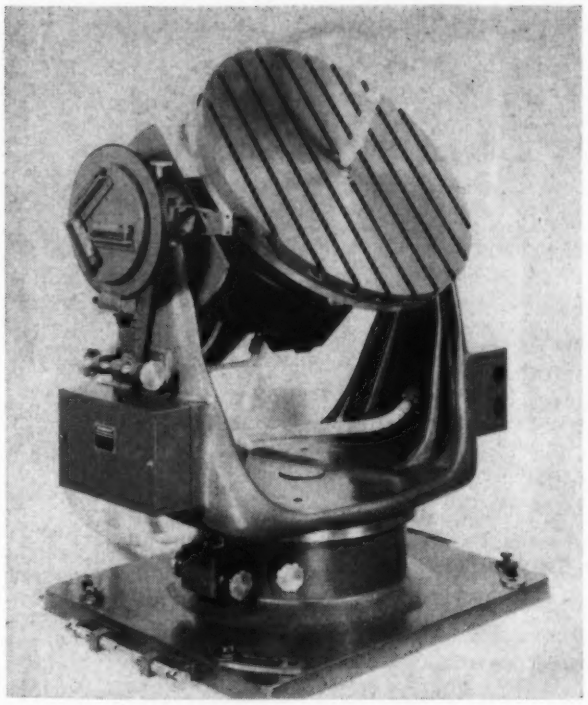


FIG. 5. SERVO MOTOR driven table, Model 066, using precision gear drive can be used for simultaneous rate mode testing of a number of gyro units or for servo mode testing of a single unit or system.

tachments have been provided on this type of table.

Servo tables using conventional servo motor drives with precision spur gearing are also used. Fig. 5 shows such a unit which provides both servo and rate modes of operation, and which can therefore be used for simultaneous rate mode testing of a number of gyro units, or for servo mode testing of a single unit or system.

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Processing & Updating Magnetic Tape Files

J. C. HAMMERTON*

This analysis evaluates the effectiveness of four systems for maintaining magnetic tape files in relation to (1) the activity of the files, and (2) the efficiency of using magnetic tape.

FILE MAINTENANCE is a problem common to all business systems and many instrumentation systems. In general terms, the problem is to modify existing records in accordance with new data received. Conventional procedures involve the location of the relevant records in a filing cabinet, modification of the record by manual entry, and re-insertion of the record in its right place in the filing cabinet.

When the basic records are stored in a reference file consisting of many reels of magnetic tape, the procedure is fundamentally the same. The existing records have to be located and altered in accordance with new data which has been consolidated on a separate transaction tape.

The new data may consist of additions, modifications and deletions. For example, the reference file of an insurance company may be changed by addition of a new policy, by recording the latest premium payment on a current policy, or by deletion of a matured policy.

If the number of unit records undergoing alteration at any one time is a large percentage of the total number of records in the file, the "activity" of the file is said to be high. Conversely if only a relatively few records are changed, the activity is low.

Tape Records

Customarily a unit record is recorded on magnetic tape with gaps of unrecorded tape separating it from the adjacent records. The gaps enable the tape-handling mechanism to stop the tape after one record has been read, and some time later to restart the tape and get it up to running speed before reaching the next record. The gaps, therefore, are necessary; they do, however, constitute a wastage of the storage medium. If the unit record is long (600-700 characters), the wastage is small; if short (35-70 characters), the wastage is significant. *Tape utilization*—i.e., the ratio of the length of recorded tape to the total length of tape, is included in the analysis as a parameter.

*Author was with Radio Corporation of America when article was written.

Updating Techniques

There are many different methods of updating magnetic tape files. Five methods are described in this section and four are analyzed.

System 1—Computer ("read" after "write")

The most elementary method of updating a reference file is to use a simple computer which can only perform one instruction at a time (Fig. 1).

The reference file and the transaction tape are connected to input trunks of the computer. In both of them, the records are ordered by the same identifying criterion—e.g., policy number.

Having lodged the first transaction in the computer, the records on the reference tape are read-in until a match is found.

In the case of a record which does not match a transaction record, the process time is equal to the read-in time (T_r) plus the time to compare the identifying criteria, thus ascertaining that no match exists, plus the write-out time (T_w). For practical purposes this time is equal to ($T_r + T_w$).

If a match is found, the process time is increased by the compute time (T_c) necessary to produce an updated record.

After using the first transaction record to update an inventory record, the second transaction record is read in to the computer and the search of the reference file repeated.

The fundamental objection to this method is that, since file-searching is a relatively simple task for the computer, the computer is used uneconomically.

System 2—Computer ("read" while "writing")

One method of alleviating this problem is to use a computer which has the ability to read into and write out of its memory simultaneously. This feature enables the n^{th} record to be transcribed to the output tape while the $(n + 1)^{th}$ record is being read in.

Consequently the process time per record is equal to the read-in time (T_r) if no match is found, and to the read-in time plus the compute time if a match is found.

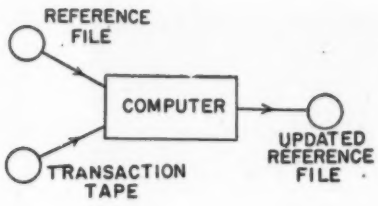

FIG. 1. SIMPLEST updating technique uses sequential read and write operations.

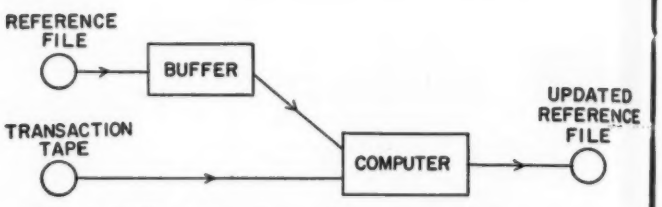

FIG. 2. USE of a buffer reduces read time.

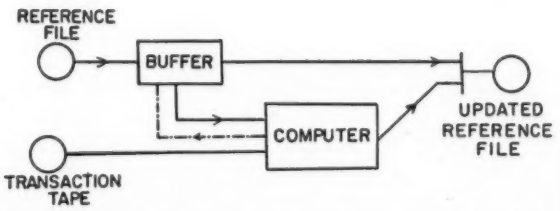

FIG. 3. BUFFER transfers record to computer only if a "match" is found.

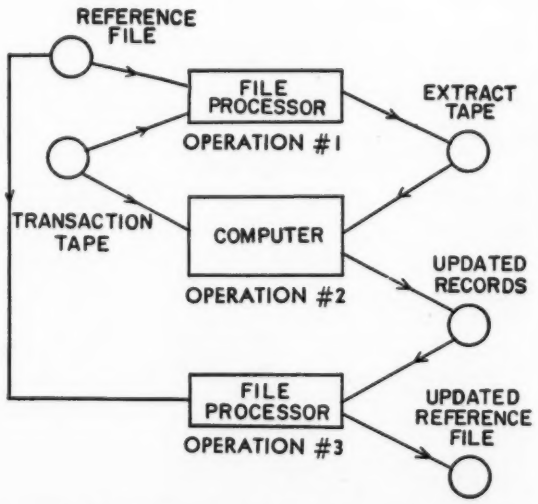

FIG. 4. FILE PROCESSOR technique prepares a tape holding only records that will be changed. Operation 1 is to prepare extract tape; operation 2 is to update active records; operation 3 is to replace old records by updated records.

System 3—Buffer Storage Device

The performance of a computer which does not have the ability to read while writing can be improved by the use of a buffer storage device (Fig. 2). Essentially this is an extension of the computer's memory with its own addressing matrix. Information can be transferred from buffer to computer or computer to buffer at a much higher rate than information is transferred to or from tapes. Typically the latter takes place at 30 kc/s while the transfers between memories can be effected at 300 kc/s.

One method of using a buffer storage device is to route all the reference records through it. The records are then available to the computer on demand. Immediately the n^{th} record has been transferred to the computer, the $(n+1)^{th}$ record can be read in to the buffer storage and held until the computer has processed the n^{th} record. The transaction records are read into the computer directly since all the information contained in them is relevant to the updating operation.

If no match is found, the process time per record is equal to the read-in time plus the buffer-to-computer transfer time. (The time required to compare criteria is small.)

If a match is found, a further time must be added equal to the compute time plus the write-out time minus the read-in time (providing this quantity is positive).

An alternative method is to transfer a record from buffer to computer only if a match is found (Fig. 3). If no match occurs, the record is transferred directly to the output tape from the buffer while the next record is read in.

This method necessitates a buffer storage device which can (a) read while writing and (b) compare an identifying criterion in it with an identifying criterion in the computer.

System 4—File Processor and Computer

A different approach to the problem is found in the use of a special-purpose machine commonly referred to as a *file processor* (Fig. 4).

The purpose of this machine is two-fold. It extracts from the reference file copies of those records which have to be updated in accordance with the data consolidated on the transaction tape. Consequently, only active data are presented to the computer and the computer can complete its task in the minimum time. The second operation performed by the file processor is to return the updated records to the reference file in place of the out-of-date information.

The updating of the reference file is, therefore, accomplished in three basic operations (Fig. 4). However, if the updating operation is performed regularly and frequently, the first and third operations can be combined. For example, on a daily cycle the transaction tape resulting from Tuesday's work can be used to extract the relevant records from the reference file while the updated records from Monday's work are returned to the file. As the two operations are performed simultaneously, the total processing time is reduced.

TERMINOLOGY

T_r = read-in time from tape to computer, file processor or buffer
= T_s, time to start the tape and reach the first character; + time to transfer the record
= $T_s + h/v$ where h is the average length of a record in inches and v is the tape speed in inches/sec.

d = length of gap of blank tape between records in inches

x = fraction of a tape which stores useful data = $h/(h + d)$

T_c = time to perform the necessary computation on an active record

T_w = time to transcribe a record to a tape from the computer, the file processor or the buffer storage device

T_{bd} = time to transfer a record from buffer to computer or computer to buffer = h/kv

k = ratio of information handling rate in computer and buffer to information handling rate to and from tape.

L = length of a reel of tape in inches

N = number of records per reel of tape = $L/(h + d)$

y = fraction of the records in the reference file which require servicing during a particular cycle of operation

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The analysis which follows assumes that the file processor can simultaneously extract from and return to the reference file in this manner.

It further assumes that the machine is designed so that the time taken to process a reel of tape is approximately equal to the running time of the tape. In low-activity applications, this assumption is justified if the reference tapes are only stopped when a match occurs with either a record on the transaction tape or a record on the updated tape. By implication the file processor must be able to read, perform its limited computation and write simultaneously.

Comparison of Processing Times

In the following sections, the four systems described are analyzed with respect to processing time and machine cost.

The analysis is made with reference to two different operations. In one the records have an average length equal to the gaps of unrecorded tape between records (tape utilization factor $x = 0.5$). In the other, the records have an average length equal to nine times the length of the gap ($x = 0.9$).

The time to introduce the transaction records is excluded from the analysis because it affects all the systems equally with the exception of System #4. Since the latter is used only in low activity applications the exception is unimportant.

The method of analysis is valid for other systems but the results must be applied with caution if any of the typical values are altered.

System 1—Computer ("read" after "write")

The processing time (T_1) is the sum of the time to read and write the inactive records and the time to read, compute and write the active records.

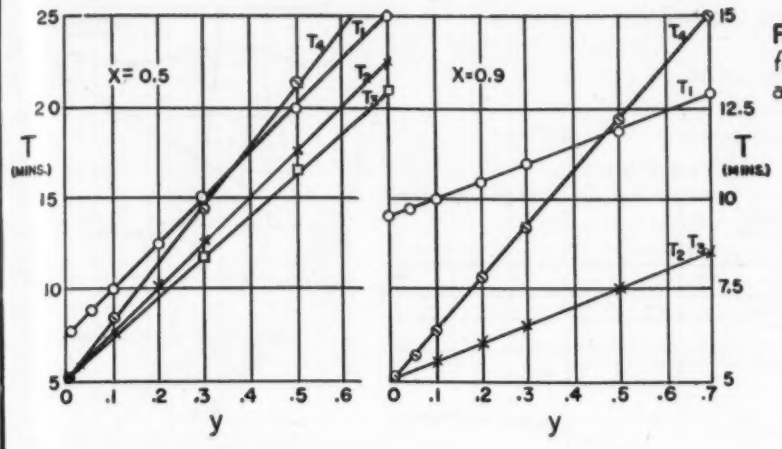


FIG. 5. PROCESSING times for y between 0.01 and 0.7, at x = 0.5 and x = 0.9.

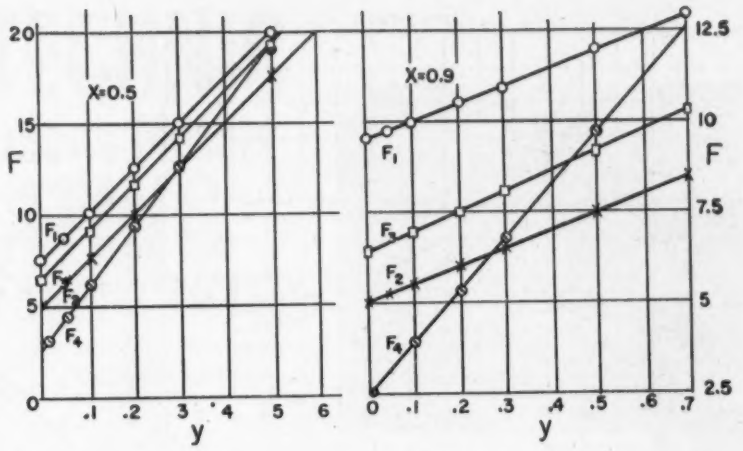


FIG. 6. FIGURES of demerit.

$$T_1 = (T_r + T_w)\, N\,(1-y) + (T_r + T_c + T_w)\, Ny$$

as $N = L/(h+d)$

$$T_1 = [(T_a + T_c y)\,(1-x)/d + 2x/v]\, L \qquad (1)$$

System 2—Computer ("read" while "writing")

The processing time (T_2) is the sum of the time to read the records plus the time to compute the active records. The write-out time is not included because the $(n+1)^{th}$ record is read in while the n^{th} record is written out.

$$T_2 = T_r N + T_c N y = [(T_a + T_c y)\,(1-x)/d + x/v]\, L \qquad (2)$$

System 3—Buffer-Storage Device

The system described utilizes a buffer storage device between the reference file and computer. As soon as the n^{th} record has been transferred to the computer from the buffer, the $(n+1)^{th}$ record is read into the buffer. The latter action, therefore, takes place concurrently with writing out the n^{th} record, if it is inactive, or the computing and writing out, if it is active.

If no match is found, the read-in time governs the instruction time. If a match is found, the governing time is T_r or $(T_w + T_c)$, whichever is greater.

A time T_{bd} is included for transferring the record from buffer to computer.

$$T_3 = (T_r + T_{bd})\, N + (T_c + T_w - T_r)\, Ny$$

where $T_c + T_w \geqq T_r$

$$T_3 = [\{T_a(1-y) + T_c y\}(1-x)/d + (1+1/k)\,(x/v)]\, L \qquad (3)$$

System 4—File Processor and Computer

The processing time (T_4) consists of a time T_a taken by the file processor to extract some active records from the reference file and return others to it, and a time T_b taken by the computer to process the extracted active records.

T_a is assumed equal to the running time of the reference file. This assumption is true for an ideal file processor and valid for a file processor performing a low-activity operation. Because this assumption is made, the activity of the records handled by the file processor is irrelevant.

The computer in this example does not have the ability to read and write simultaneously.

$$T_a = L/v \qquad (4)$$

$$T_b = (T_r + T_w + T_c)\, Ny = [(T_a + T_c)\,(1-x)/d + 2x/v]\, Ly \qquad (5)$$

$$T_4 = T_a + T_b \qquad (6)$$

Evaluation of Systems

In order to evaluate the four systems, the following typical values for the system constants are used.

T_a = 5 milliseconds
d = 0.5 inches
v = 100 inches/sec
L = 30,000 inches
k = 10

The value of T_c depends on the operation being performed. It cannot readily be related to the average length of the record because the record may be padded with "copy" information which takes no part in the computation. As a representative figure, 50 milliseconds is used. If the average time per instruction is 100 microseconds, 50 milliseconds represent a program of approximately 500 instructions per active record which is quite modest.

Using these values, the processing times have been plotted in Fig. 5 for values of y between 0.01 and 0.7.

It will be seen that, time-wise, Systems 2 and 3 are approximately equivalent. Also that System 4 is only efficient at low values of y—i.e., in low-activity applications.

The times are longer for x = 0.5 than for x = 0.9 because there are more records on the tape when x is low. Consequently more stopping and starting of the tape is involved.

Figure of Demerit

System cost must be taken into account to improve the comparison.

To do this, a figure of demerit (F) is used equal to the processing time (T) multiplied by the system cost expressed as a fraction of the cost (C) of the basic computer.

Thus the figure for System 1 is numerically equal to the processing time T_1.

In practice the provision of the ability to "read-while-writing" does not materially increase the cost of the computer so that the figure for System 2 is T_2.

System 3 uses a buffer storage device of which the cost can be expressed as \$Cm where m = 1/5, approximately, with existing techniques. The figure of demerit for system 3 is, therefore, $T_3(1+m)$ because both the buffer and the computer are used for time T_3.

System 4 uses a file processor and a computer. The cost of the file processor can be expressed as \$Cn. It is assumed that a reasonable value for a design approaching the ideal is n = ½. The file processor is in use for a time $T_a = L/v$, and the computer for a time T_b where $T_b = (T_4 - T_a)$. Thus the figure of demerit for System 4 is $T_a n + (T_4 - T_a)$.

The values are plotted in Fig. 6.

Conclusions

The relative merits of the systems analyzed can be summarized as follows;

I. System 1, the basic computer, is the least efficient, as was expected.

II. System 4, the computer and file processor, is the best system on the time-cost basis when the file activity is less than 25%.

III. System 2, the computer with the "read-while-writing" facility, is the best system on the time-cost basis when the file activity is greater than 25%.

IV. On the basis of time alone, System 2 is the best system no matter what the activity.

V. System 3 is only to be recommended as a method of improving the performance of a computer which lacks the ability to read-while-writing.

VI. These conclusions are valid for storage utilization factors of 50% and 90%. Consequently it is inferred that they are valid for all reasonable values of this parameter.

The conclusions stated above are based solely on consideration of time and cost. They do not reflect any thinking about the advantages which accrue in systems with only one type of major data-processing machine—namely easier maintenance, more flexible scheduling, and more uniform control methods.

Acknowledgments

The author wishes to thank the Radio Corporation of America for permission to publish this paper and to acknowledge the helpful criticism of his colleagues during its preparation.

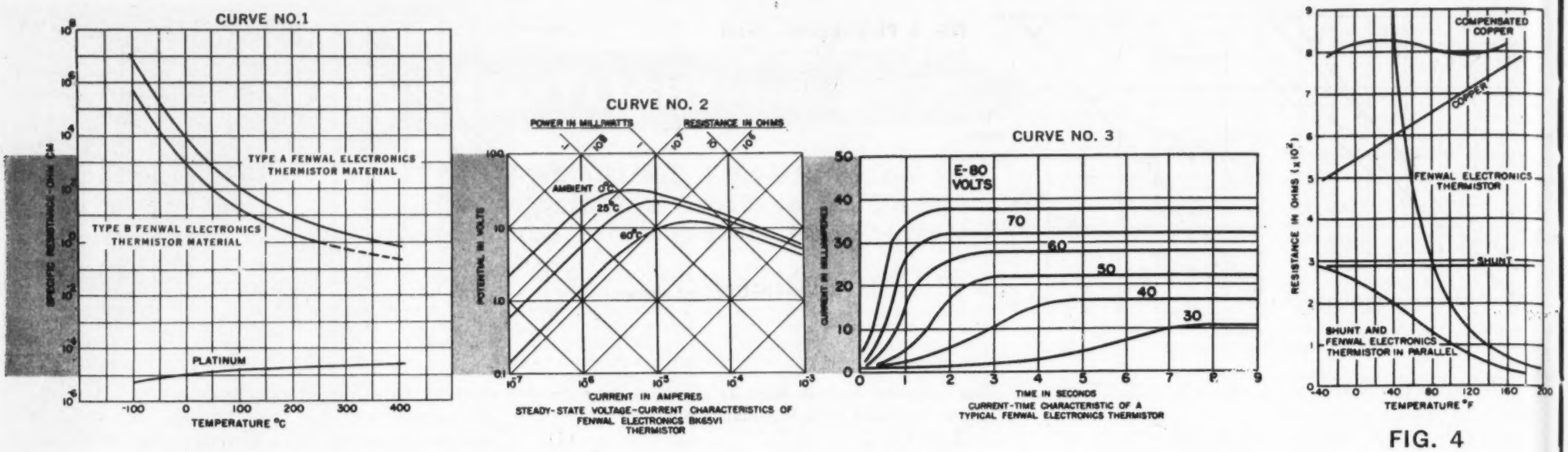


FIG. 4

The Thermistor—a Versatile Thermal Transducer

Thermistors are "thermal resistors" or resistors with a high negative temperature coefficient of resistance. As the temperature increases, the resistance goes down and as the temperature decreases, the resistance goes up. This is just opposite to the effect of temperature changes on metals. Thermistors are semi-conductors of ceramic material made by sintering mixtures of metallic oxides such as manganese, nickel, cobalt, copper, iron, and uranium.

Three important characteristics of thermistors that make them useful in electronic and electrical circuits are their resistance-temperature, voltage-current and current-time characteristics.

Resistance-Temperature Characteristic: The resistance of a thermistor as measured at very low power is solely a function of its absolute temperature. This resistance is called R_o, which means the resistance at essentially zero power.

The mathematical expression which relates the resistance and the absolute temperature of a thermistor is as follows.

$$R_o\,(T)/R_o\,(T_o) = \epsilon^{\beta}\,(1/T - 1/T_o)$$

Where: $R_o\,(T)$ is the resistance at absolute temperature T.
$R_o\,(T_o)$ is the resistance at absolute temperature T_o.
ϵ is 2.718

β is a constant which depends on the material used to make the thermistor (approximately 4000). The temperature characteristic α of the thermistor is approximately equal to $-\beta/T^2$ at any absolute temperature T.

Fig. 1 shows the resistance variation of two basic Fenwal Electronics thermistor materials with temperature, and also shows the resistance variation of platinum for comparison. Between the temperature of −100°C and 400°C., there is a change of ten million to one in resistance of thermistor materials whereas platinum changes by only ten to one over the same temperature range.

Voltage-Current Characteristic: If a very small voltage is applied to a thermistor, a small current will flow which does not produce enough heat in the thermistor to heat it measurably above its surroundings. Under these circumstances, Ohm's Law will be followed and the current will be proportional to the applied voltage. However, if the voltage is gradually increased, the current will increase, and the heat generated in the thermistor will finally begin to raise its temperature above that of its surroundings. The resistance will consequently be lowered and more current will flow than if the resistance had remained constant (Fig. 2). In the latter portion of the curve, the thermistor is exhibiting a negative resistance characteristic. Under normal operating conditions the temperature may rise 200° or 300°C and the resistance may be lowered to 1/1000 of its value at low current.

Current-Time Characteristics: If a voltage is applied to a thermistor and resistor in series, a current will be determined by the voltage and the total circuit resistance. If the voltage is high enough, some heat will be generated in the thermistor which will lower its resistance and more current will flow. This, in turn, will heat the thermistor still more and lower its resistance still further. This process will continue until the thermistor reaches the maximum temperature possible for the amount of power available in the circuit, at which time a steady state will exist.

Since the thermistor has a certain mass, it takes time for it to be heated to its maximum value and this time is a function of the mass of the thermistor, the value of the series resistance and the applied voltage.

Fig. 3 shows that the time delay for the circuit to reach maximum current for a given thermistor is a function of the applied voltage. By suitable choice of thermistor and associated circuitry, it is possible to produce time delays from 0.001 seconds to several hours.

FIG. 4. COPPER temperature characteristic in meter coil (4A) is corrected by shunted thermistor.

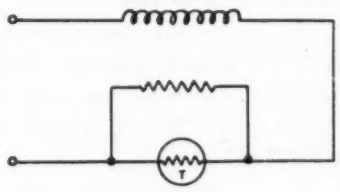


FIG. 4A

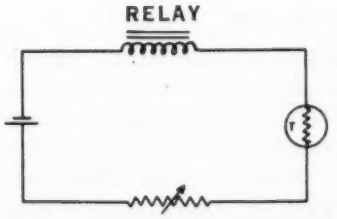


FIG. 5. TEMPERATURE Control Circuit.

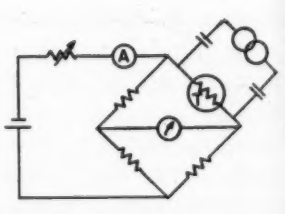


FIG. 6. POWER measurement for RF energy.

How Thermistors Are Used

The number of successful thermistor applications is growing rapidly and the future use of thermistors appears to be limited only by the imagination and enterprise of skilled engineers. Three typical applications are suggested below:

Temperature Compensation: Most circuit elements have a positive temperature coefficient of resistance such as the copper wire in a meter coil (Fig. 4). A thermistor may be used to compensate such a coil so the meter resistance is substantially constant over a wide temperature range. The thermistor is shunted by a resistor so that resultant negative temperature co-

efficient of resistance is equal to the positive coefficient of the copper.

Temperature Control: A sensitive temperature control may be made by placing a thermistor (Fig. 5) in one leg of a bridge circuit, a variable resistor in another leg, and a polarized relay across the output. When the thermistor becomes warm, the relay will operate in one direction and when the thermistor becomes cold, the relay will operate in the opposite direction. The point of operation may be adjusted by changing the value of the variable resistor.

A very sensitive control may be made by applying ac to the bridge and placing a high gain amplifier between the bridge and the relay. Such controls have operated to a precision of .001°F with ease.

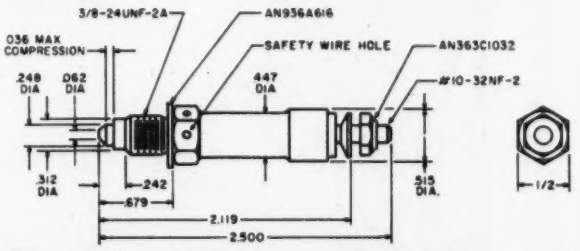
Power Measurement: If a bead thermistor of 2000 ohms is placed in a 200 ohm bridge circuit with a variable resistor in series with the bridge (Fig. 6) the current may be increased gradually until the thermistor heats up enough to lower its resistance to 200 ohm at which point the bridge will be in balance. This current may be measured and the dc power in the thermistor calculated. If a source of high frequency power is applied to the thermistor through suitable capacitors, it will be still further heated and the bridge will be unbalanced. The dc power may then be reduced until the bridge balances again and the new dc power calculated. The difference in the two dc power calculations will be the HF power. (*From 20-page "Thermistor Manual", Fenwal Electronics, Inc., Framingham, Mass.*)

FOR THIS LITERATURE CIRCLE 108 ON READER-SERVICE CARD

Tip-Sensitive Heat Limit Switch

New rugged, precision thermal switch for military and industrial applications called the "Tip-Stat," Type Q-1 (See Figure) is most effectively used where inner temperatures must be controlled. Typical applications include its use in aircraft generators where it signals a warning to actuate a control when the windings reach dangerously high temperatures.

When supported in a bearing housing with its tip pressed against the bearing race or shell, it signals any bearing overheat condition in time to prevent serious damage.



The switch is factory preset to actuate at any point from 20° to 550°F, employing a hermetically-sealed inner cartridge. The reaction time is less than 0.5 seconds and temperature differential is from 1° to 2°F. Repeatability of operation is within ±1°F. Contact rating is 1½ ampere resistive or ½ ampere inductive, 115 v ac or 28 v dc. (*From 8-page catalog, "CPI Bi-Metal Thermal Switches," Control Products, Inc., 280 Ridgedale Ave., East Hanover, N. J.*)

FOR THIS LITERATURE CIRCLE 109 ON READER-SERVICE CARD

Modern Permanent M

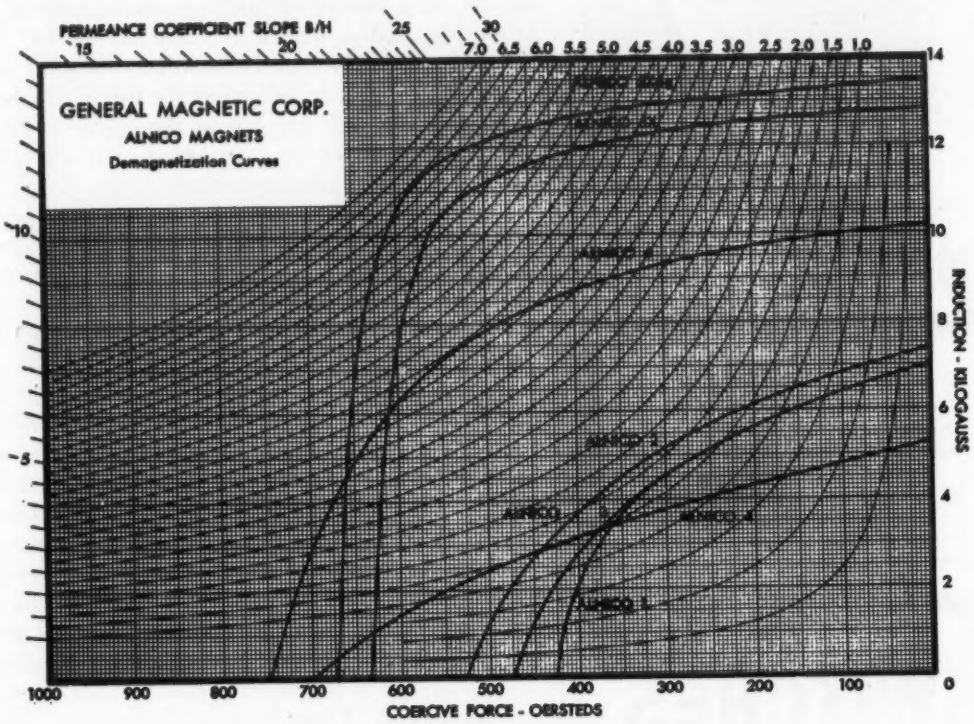


FIG. 1. CHARACTERISTIC Demagnetization Curves, Alnico Magnets.

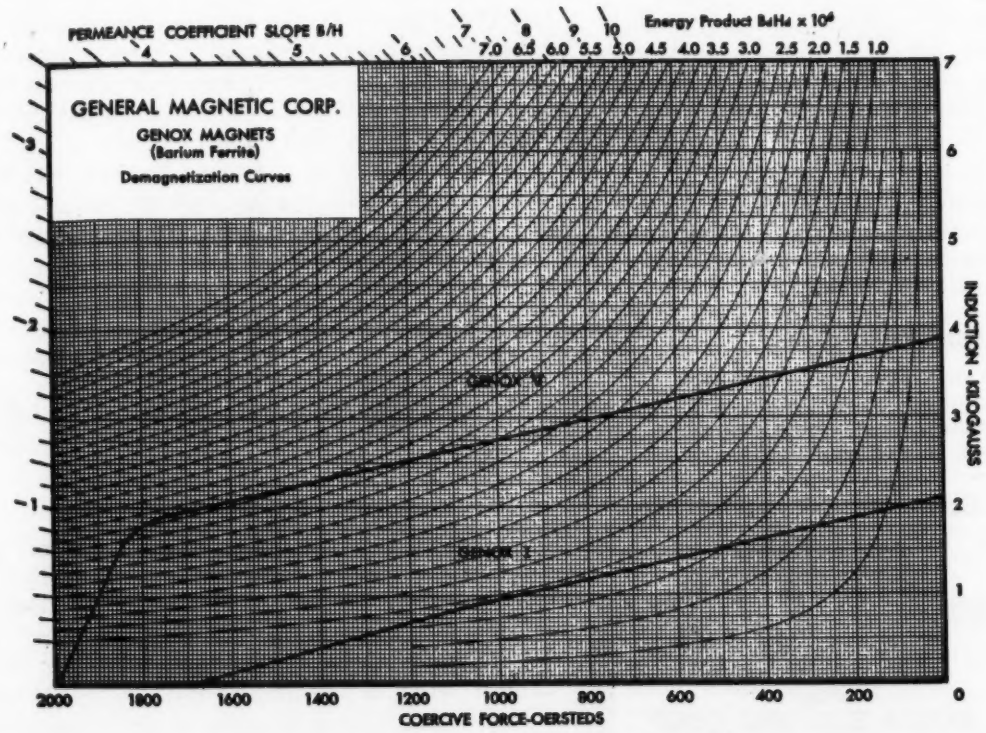


FIG. 2. CHARACTERISTIC Demagnetization Curves, Genox® Magnets.

...nMagnets

Modern permanent magnets of high-energy Alnico are now available in many convenient pre-machined forms. Today a one-inch Alnico block will have more magnetomotive force at its poles than a 6-inch bar of equal cross-section made from old chrome-steel materials, which were formerly bent into a horseshoe to bring its poles the same distance apart.

The length and cross section of a magnet materially affects the magnetic field it is capable of producing in any magnetic circuit. The metallurgical composition (Fig. 1) also is a vital factor in determining the magnetic properties and its characteristics under environmental stresses.

Magnetic alloys are cast into approximately the size and shape needed for stock and sample applications. After casting a melt of the appropriate alloy to meet the end-use specifications, the rough magnets are shot-blasted, tumbled and subjected to preliminary grinding to clean and size. Heat-treating then makes these metallic forms into powerful magnets. Inherent magnetic "domains," which are chains of atoms grouped to form the smallest magnetic unit, are made mobile by heat. When cooled in a strong magnetic field, these domains literally freeze in a magnetic state.

In addition to the metallic magnetic alloys, a new ceramic magnetic material, Genox®, is now available in many standard and sample shapes. Genox is an oxide material (barium ferrite), not a metal. Electrically it is an electrical insulator and has a magnetic permeability of approximately one, the same as air. Therefore, the parts which are magnetized do not affect the magnetic circuit leakage field. This means that salient poles are not usually required.

Genox is made in two grades, chemically similar but processed differently. Each has its individual applications (Fig. 2). Genox V is magnetically stressed in the preferred direction of magnetization during the manufacturing process resulting in a magnetic energy product about three times that of the unoriented Genox 1. Genox weighs approximately 2.8 oz/cu-in, while Alnico weighs about 4.23 oz/cu-in.

In comparison with Alnico V the Genox materials have a lower saturation and residual magnetization—Alnico V, approximately 12,000 gauss; Genox 1, 2,000 gauss; and Genox V, 4,000 gauss. Both Genox 1 and Genox V have a coercive force approximately three times that of Alnico V. These characteristics indicate that for any given application Genox will be larger in cross section than Alnico V but shorter from pole to pole. Total volume of Genox will usually be greater, but frequently at lower cost. Applications include: speaker magnets, alternators, tachometers, TWT focussing assemblies, etc. (*From 50-page catalog, "Guaranteed Magnetic Components", General Magnetic Corporation,* 10001 *Erwin Ave., Detroit* 34, *Mich.*)

FOR THIS LITERATURE CIRCLE 110 ON READER-SERVICE CARD

CIRCLE 39 ON READER-SERVICE CARD

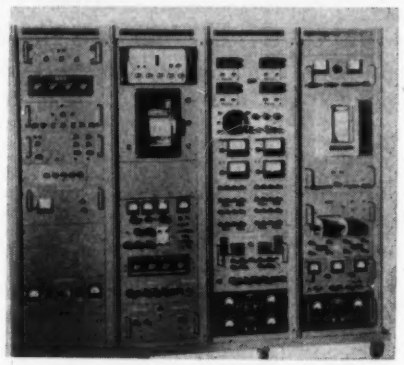
CIRCLE 40 ON READER-SERVICE CARD

MSD new products

INERTIAL GUIDANCE TRANSDUCERS

GYRO TEST CONSOLE

A complete test console includes torque-to-balance feedback loop; magnetic suspension panel; compensation; dual photocell amplifiers; gyro wheel

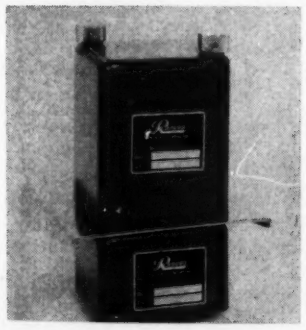


supplies; frequency source; dual demodulator and servo amplifier required for MIT Type "D" gyro turntable, and for gyros developed at M.I.T. Full instrumentation and metering, and all power supplies are also included.—*Northeastern Engineering, Inc., Manchester, N. H.*

CIRCLE 119 ON READER-SERVICE CARD

DUAL-CHANNEL AMPLIFIER

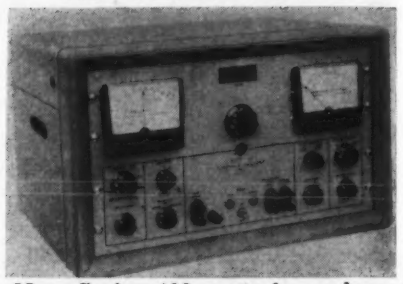
New dual-channel transistorized amplifier for compensated resolver applications features a parallel summation input circuit which can ac-



cept as many as five inputs per channel. Voltage transfer ratios can be maintained to an accuracy of 0.1% over the operating temperature range of — 55° to 105°C. Amplifiers operate at a signal frequency of 400 cps, provide output of 26 volts rms.—*Components Marketing Div., Reeves Instrument Corp., Roosevelt Field, Garden City, N. Y.*

CIRCLE 120 ON READER-SERVICE CARD

SERVO ANALYZERS



New Series 400 controls analyzers provide a self-contained signal generator, provide signals over frequency ranges up to 10,000 to 1. Three models cover frequency ranges of 0.3-20 cps, 0.003-30 cps, and 0.02-200 cps. Frequency and amplitude to ±2% of full scale accuracy.—*Superior Manufacturing and Instrument Corp.*, 154-01 *Barclay Ave., Flushing* 55, *N. Y.*

CIRCLE 121 ON READER-SERVICE CARD

INERTIAL GYRO TEST

New data recording system, used with MIT Type D turntable supplies mean solar and sidereal time base to stability of 5 parts/10^8/wk and includes electronic digital voltmeter with printer readout; neon 6-digit timing unit; averaging unit and 11-digit printer recorder.—*Northeastern Engineering, Inc., Manchester, N. H.*

CIRCLE 122 ON READER-SERVICE CARD

RATE GYRO

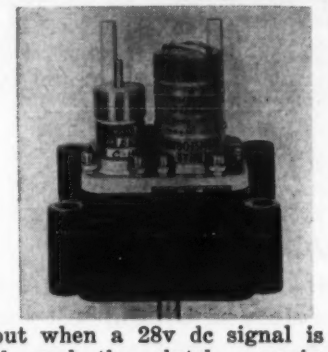
New dc rate sensor, including hermetically-sealed gyro, dc-ac inverter and signal pickoff, operates from a 28 v dc input. This is inverted to drive

the gyro motor; also the output of the pick-off is demodulated, balanced, gain-adjusted and filtered, providing dc outputs up to 12 volts. Resolution is below 0.05%, constant damping coefficient is within ±0.15% of nominal, linearity is within 1% of maximum rate, zero calibration is 0.01 to 0.02% of maximum rate, and life is 500 hrs min.—*R. C. Allen Aircraft Instrument Div.*, 333 *Commerce Ave., S. W., Grand Rapids, Mich.*

CIRCLE 123 ON READER-SERVICE CARD

POSITION TRANSDUCER

New miniature position transducer for aircraft control converts shaft inputs up to 50° to a precise linear

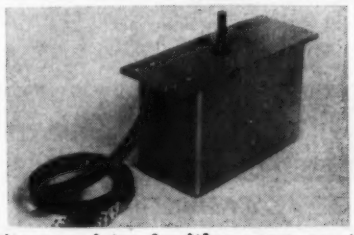


output when a 28v dc signal is applied, and the clutch energized.—*Clifton Precision Products Co.*, 5050 *State Rd., Drexel Hill, Pa.*

CIRCLE 124 ON READER-SERVICE CARD

SYNCHRO TRANSMITTERS

New Series PX-1 synchro transmitters supply linear or angular position information to a remote location from electro-mechanical devices.



Units consist of either one or two Type 23TX6 synchro transmitters geared to a shaft at different ratios to give maximum flexibility. System accuracies range from 0.05% to 0.01%.—*Scientific-Atlanta, Inc.*, 2162 *Piedmont Road, N. E., Atlanta* 9, *Georgia.*

CIRCLE 125 ON READER-SERVICE CARD

SYNCHRO TESTER

New synchro tester measures major characteristics in MIL-S-20708A including electrical zero, electrical error, fundamental null and total null. Operation is semi-automatic with switch manipulation by rotary solenoids, and all outputs are direct reading, dc analog voltages.—*Theta Instrument Corp.*, 520 *Victor St., Saddle Brook, N. J.*

CIRCLE 126 ON READER-SERVICE CARD

LINEAR TRANSFORMER

New size 8 linear transformer Model 9708-005 can deliver ½-w power into a 500-ohm load while retaining

its linearity of .33% over a range of ±30°. Has a 26-v, 400-cycle input, with phase shift control, capabilities to ±30'.—*imc Magnetics Corp.*, 6058 *Walker Ave., Maywood, Calif.*

CIRCLE 127 ON READER-SERVICE CARD

TRANSDUCERS

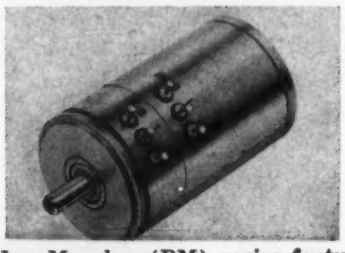
ALTITUDE CONTROL TRANSDUCER

New economical Model 571 altitude control transducer can be used in ex-

pendable target drones or in tactical missile and aircraft applications. Specifications: functional range, ±0.5 psi; operating range to 80,000 ft.; dynamic error band, ±2%;—*Bourns, Inc., 6135 Ave., Riverside, Calif.*

CIRCLE 128 ON READER-SERVICE CARD

POTENTIOMETER

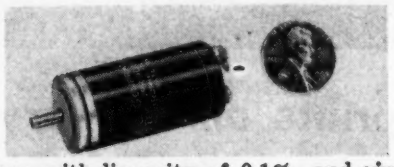


New Megohm (PM) series features Resistance Range—1 Meg to 10 Megs ±5%; Linearity—1% std; 0.5% special.—*Accuracy, Inc., 4 Gordon St., Waltham 54, Mass.*

CIRCLE 129 ON READER-SERVICE CARD

DC TACHOMETER

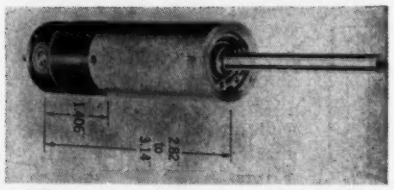
New Model SS-779E-1 Size 8 dc tachometer has output of 3 v/1000



rpm with linearity of 0.1%, and ripple not over 3% of dc output.—*Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.*

CIRCLE 130 ON READER-SERVICE CARD

TIMER MOTOR TACHOMETER



New ⅞" diameter Type 9001-00 permanent magnet motor withstands over 500 G shock; negligible speed variation from –67° to 167°F results from dry lubrication. Gear ratios range from 6:1 to 46,656:1, with peak loads to 500 oz-in.—*John Oster Mfg. Co., Avionic Div., Racine, Wis.*

CIRCLE 131 ON READER-SERVICE CARD

PRECISION PRESSURE SWITCH

New Model 400100 precision pressure switch for absolute, differential or gage pressure has accuracy of

½% and is available in any pressure setting from 0.2 to 250 psi. Wide band of adjustment is provided for a given nominal switch pressure.—*Wallace O. Leonard, Inc., 373 S. Fair Oaks Ave., Pasadena, Calif.*

CIRCLE 132 ON READER-SERVICE CARD

TRIMMER POT

New subminiature trimmer potentiometer Model 540 features 2-watt ratings, operation to 200°C, and humidity-proofing.—*Handley, Inc., 12960 Panama St., Los Angeles 66, Calif.*

CIRCLE 133 ON READER-SERVICE CARD

SUB-MIN TRIMMER POT

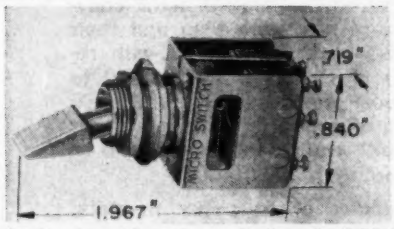
New general purpose trimmer potentiometer in resistances from 10

through 100,000 ohms ±10% are available with insulated wire leads, solder lugs or end-mounted printed circuit pins.—*Atohm Electronics, 7648 San Fernando Rd., Sun Valley, Calif.*

CIRCLE 134 ON READER-SERVICE CARD

INDICATING TOGGLES

Bright aluminum tabs provide instant position indication with new compact toggle switches, each of

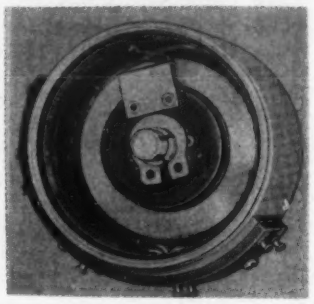


which provides two isolated SPDT circuits UL listed at 5 amp, 125 or 250 v. Dry circuit switches also available.—*Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.*

CIRCLE 135 ON READER-SERVICE CARD

POT TAPS RE-SETTABLE

New 2" diameter Protractatap precision potentiometer provides up to 8 re-settable taps which can be adjusted by eye without tools to ½° ac-

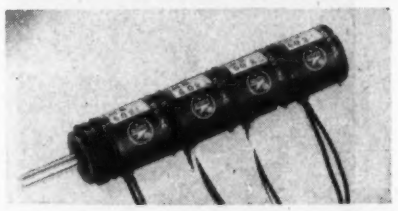


curacy. Initial accuracy is maintained over wide ranges of temperature, humidity vibration and other critical factors.—*Accuracy, Inc., 4 Gordon St., Waltham 54, Mass.*

CIRCLE 136 ON READER-SERVICE CARD

MULTIGANG POTS

New precision wire-wound ½" pots in multigang configurations up to six gangs, servo or bushing mounted, are supplied with choice of ball or jewel bearings. Standard linearity is 0.3%

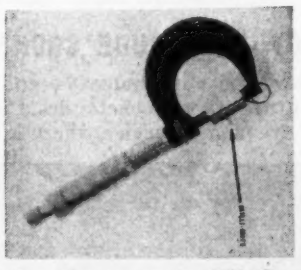


in standard resistances from 100 ohms to 250K ohms; power ratings are up to 2.5 watts at 65°C and max operating temperature is 150°C.—*ACE Electronics Associates, Inc., 99 Dover St., Somerville, Mass.*

CIRCLE 137 ON READER-SERVICE CARD

INERTIAL SWITCH

New miniature inertia switch Model 6UO-200 is preset to respond to ac-



celeration forces up to 250 G within a tolerance of ±15% of setting, operating range of −65° to +200°F. It has only one moving part, a precision-ground steel ball held against a solid base by a uniform magnetic field. When the opposing force of acceleration exceeds the magnetic force, the ball moves to close a normally open electrical contact.—*Inertia Switch, Inc., 311 W. 43rd St., New York 36, N. Y.*

CIRCLE 138 ON READER-SERVICE CARD

CONTINUOUS ROTATION POT

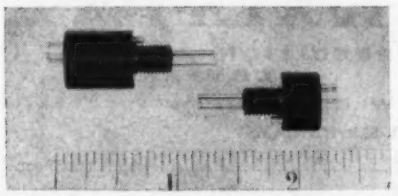
New 360° continuous rotation composition variable resistor, series

CR45, increases effective rotation from approximately 270° to 330°, makes exact resistance adjustments easier. Resistance range is 250 ohms through 10 megohms with linear resistance gradient. Rating is ¼ to ½ watt depending on resistance.—*CTS Corp., Elkhart, Ind.*

CIRCLE 139 ON READER-SERVICE CARD

MINIATURE POTS

New miniature single-turn potentiometers feature rugged construction, small size and light weight for trimming, control and servo applications.

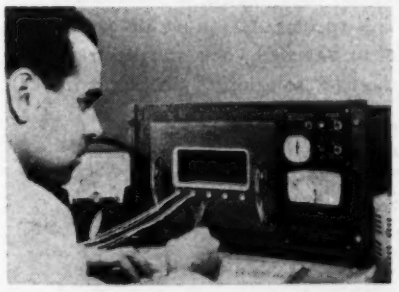


Model 140 bushing mount is 0.3" long, weighs 0.1 ounce with a standard resistance range from 50 ohms to 10 kohms, standard resistance range from 20 to 70 kohms.—*Spectrol Electronics Corp., 1704 South Del Mar Ave., San Gabriel, Calif.*

CIRCLE 140 ON READER-SERVICE CARD

THERMAL SHOCK CHAMBERS

New Portable Temperature Test Chamber with ultra-rapid cycling completes a hot-cold cycle from −100°F to 500°F in slightly less than

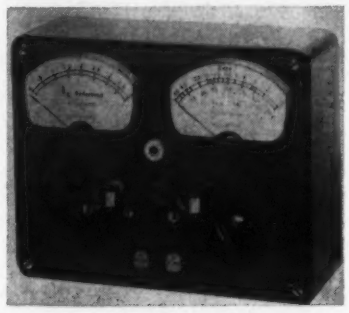


10 minutes. Window drawer, access ports for test and operational wiring, liquid CO_2 cooling and automatically programmed test cycle conserve test engineer's time. 10" x 7" x 7" test volume weighs under 50 lbs for portability.—*Delta Design, Inc., 7460 Girard Ave., La Jolla, Calif.*

CIRCLE 141 ON READER-SERVICE CARD

TRANSISTOR BETA TESTER

New Model 200 Transistor Tester measures Beta (HFE) directly on calibrated scale to accuracy of 1% at



different collector current reference levels. Accommodates PNP, NPN transistors, also power transistors, germanium diodes, selenium and silicon rectifiers.—*Westmore, Inc., Fanwood, N. J.*

CIRCLE 142 ON READER-SERVICE CARD

MIXER DIODE

First commercially available gallium arsenide microwave mixer diode, IN3096R, is specified for 24,000 mc

(K-band) first-detector operation and is housed in a coaxial package identical to that used for existing silicon K-band diodes. Gallium arsenide diode exhibits an over-all noise figure of 10.5 db, surpassing the lowest noise figure available for any K-band crystal.—*Philco Corp., Lansdale Div., Lansdale, Pa.*

CIRCLE 143 ON READER-SERVICE CARD

LOW-LOSS TUBE SOCKETS

New series Chemlec 7- and 9-pin miniature tube sockets designed for high frequency service where low loss-

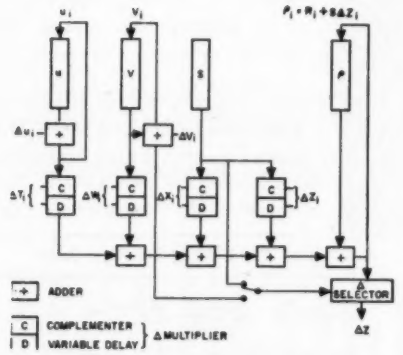
factor and low dielectric constants are required, use FEP Teflon or CTFE (chlorotrifluorethylene), both withstanding high frequency, high temperature and high voltages. Meet or exceed all JAN specs.—*Garlock Electronic Products, Garlock Inc., Camden 1, N. J.*

CIRCLE 144 ON READER-SERVICE CARD

Digital Variable Increment Computer Solves Weapon Systems Problems

GEVIC, General Electric's Variable Increment Computer, a new concept in digital computers, provides a unique combination of rapid slew, high iteration rate, and digital precision in applications formerly restricted to analog methods of computation. GEVIC is a multi-purpose stored-program digital computer employing all solid-state logic elements and circuitry.

GEVIC's ability to operate in real-time on continuously changing data permits the computer to be incorporated directly into multiple highspeed servo loops. Designed for high-performance weapon control, guidance, and navigation systems, GEVIC is particularly suited to those digital applications where small size, light-weight, and extreme reliability are additional factors affecting the choice of computing techniques.



COMPUTER block diagram is diagrammatic restatement of basic algorithm (see next page).

The Variable Increment Concept

The variable increment concept overcomes the two limitations of the fixed increment computer—slewing and rate limiting—without the expense of a multiple arithmetic section or without requiring excessively high clock frequencies:

(1) The incremental or decremental change of each variable is approximated by zero or by the closest allowed integral power of radix two (0, ±1, ±2, ±4, . . . etc.).
These increments are easily stored and transferred as sign plus binary coded exponent (e.g., $+0\,101 = +2^5 = +32$).
Multiplication of a binary coded number by an increment becomes the simple process of delaying the multiplicand by a number of digit positions equal to the power of the multiplier.
(Just as in the decimal system $19 \times 10^2 = 1900$).

(2) GEVIC usually mechanizes a more general algorithm than the integrator of the DDA. While the GEVIC concept is applicable to either differential or algebraic mathematics, the latter is usually preferred because of its ease of use and high pro-

gram efficiency (about 2 or 3:1 over the single integrator DDA).

Basic Algorithm

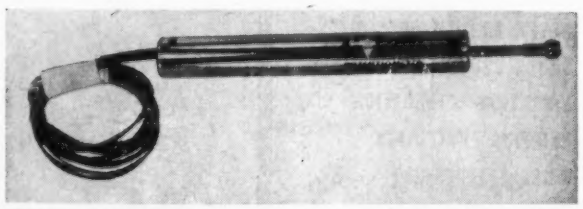
$$S\Delta Z_i + R_i = \rho_{i-1} - S\Delta Z_{i-1} + U_i\Delta T_i + V_{i-1}\Delta W_i + S\Delta X_i$$

The computer block diagram (see figure) is a diagrammatic statement of this algorithm. This algorithm can be modified to provide addition-subtraction, multiplication, division, integration, exponential filtering, and differentiation and filtering. These modifications are developed from the basic algorithm by programmed-addressing of the proper variables (ΔU, ΔT, ΔV, ΔW, ΔX, ΔZ). All arithmetic operations solved in GEVIC are exact. No approximations are used and no drift is possible. The integrative operations are as good as is possible for their configuration. (e.g., either retangular or trapezoidal integration may be programmed). (*From new 8-page brochure, GEVIC ... A New Concept in Incremental Digital Computers, Light Military Electronics Dept., Armament & Control Section, General Electric, 600 Main St., Johnson City, N. Y.*)

FOR THIS LITERATURE CIRCLE 145 ON READER-SERVICE CARD

New Linear Pots are Standardized

New Humphrey Standard Rectilinear Potentiometers, available in mechanical travels ranging from 0.50″ to 9.90″ in 0.10″ increments, and in total resistance ranges from 100 ohms/in to 20,000 ohms/in, are accurately described under a standardized stock number system.



STANDARDIZED designations describe New Humphrey Rectilinear Pots.

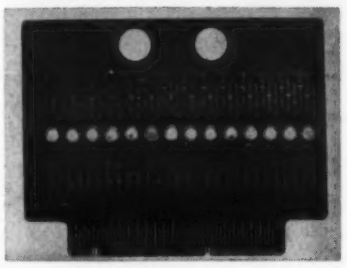
When the designer has picked the stroke and resistance he requires, he specifies the standard Humphrey model number as follows: First, he writes "RP38-" which stands for Rectilinear Potentiometer Model No. 38 Series. The next five digits have the following meaning: (1) Resistance/inch in 10K-ohms, (2) resistance/inch in K-ohms, (3) resistance/inch. in 0.1K-ohms, (4) mechanical travel in inches, and (5) mechanical travel in 0.10″.

For example, RP38-16598 would be a RP 38 series rectilinear potentiometer with a resistance of 16,500 x 9.8 = 16,1,700 ohms and a mechanical travel of 9.8″. The RP38 potentiometers have a weight of about 1 oz per travel-inch, life in excess of 500,000 cycles, and withstand vibration of 10G from 10 to 2000 cps on all axes. The RP 38 standard rectilinear potentiometer is a development of *Humphrey, Inc.*, 2805 *Canon St., San Diego 6, Calif.*

FOR MORE INFORMATION CIRCLE 146 ON READER-SERVICE CARD

NOR LOGIC MODULES

New "HS" Series modules provide transistorized Sheffer Stroke gates for use in mechanizing digital sys-

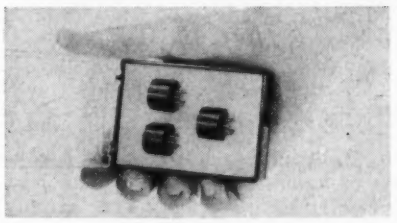


tems. Complete digital switching networks including flip-flops can be built from these gates. When Stroke gates are used with Abacus clocked flip-flops, two level logic can be operated with a single phase clock at 3mc.—*Abacus, Inc.*, 3040 *Overland Ave., Los Angeles 34, Calif.*

CIRCLE 147 ON READER-SERVICE CARD

TRANSISTOR CHOPPER KIT

Three plug-in transistor choppers with application notes comprise a circuit designer's kit to acquaint design-

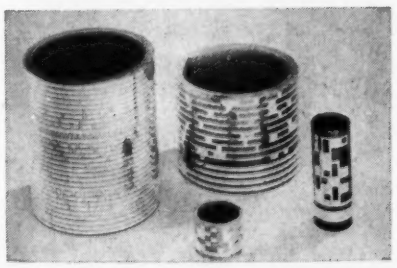


ers with solid-state chopper characteristics. Model 50P and 60P are germanium units for operation to 90°C whereas 70P is a silicon transistor unit capable of operation to 150°C.—*Solid State Electronics Co.*, 15321 *Rayen St., Sepulveda, Calif.*

CIRCLE 148 ON READER-SERVICE CARD

DRUM COMMUTATORS

New facilities for production of drum-type printed circuit commutators and encoding disc provide units



from ¾″ up to 12″ diameter with precious metal segment paths raised or flushed to insulating areas. Constant linear rate for all brushes avoids errors inherent in flat disc commutator design.—*The Sibley Co., Haddam, Conn.*

CIRCLE 149 ON READER-SERVICE CARD

CIRCLE 51 ON READER-SERVICE CARD ⟶

SUBCARRIER FM OSCILLATOR

New solid state FM telemetering subcarrier oscillator Model 0-20 having excellent data stability over the —55° to 125° C range uses silicon transistors and diodes in diecast aluminum case.—*Dorsett Electronics Labs., 119 West Boyd, Norman, Okla.*

CIRCLE 150 ON READER-SERVICE CARD

PLANAR TUBE OSCILLATOR

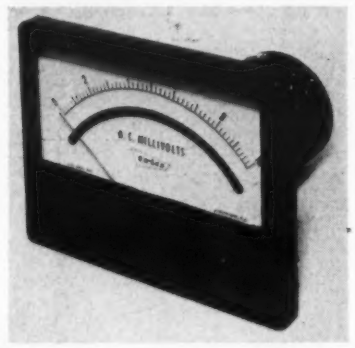
New L-band planar tube oscillator comprising dual cavity with tuned plate and tuned cathode controlled by

a single lead-screw covers range of 920 to 1400 mc with small change in output level. Designed for CW or pulse applications in low-power transmitters, signal generators, local oscillators and test fixtures; full characteristics available on request.—*General Communication Co. 677 Beacon St., Boston 15, Mass.*

CIRCLE 151 ON READER-SERVICE CARD

MINIATURE AC VTVM

New Model 130-1 AC VTVM has standard ranges to 300 v, input im-

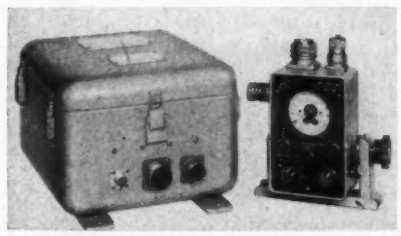


pedance of 1 megohm, and 1% accuracy. Can measure from 50 to 50,000 cps.—*Trio Laboratories, Inc., Plainview, L. I., N. Y.*

CIRCLE 152 ON READER-SERVICE CARD

SONAR SOUNDING SET

New AN/SQN 11 Sonar Sounding Set indicates depths from 5 to 100 ft to ±3% of full scale. Transistor-

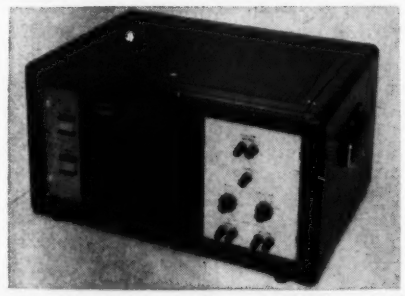


ized, lightweight, low-cost unit consists of remote indicator-control box, transmitter-receiver-power supply box, and through-the-hull transducer. Operates on input power of 115 v ±15%, 60 cps ±2%, 30 watts between 0° to 50°C.—*Kearfott Div., General Precision Inc., 1150 McBride Ave., Little Falls, N. J.*

CIRCLE 153 ON READER-SERVICE CARD

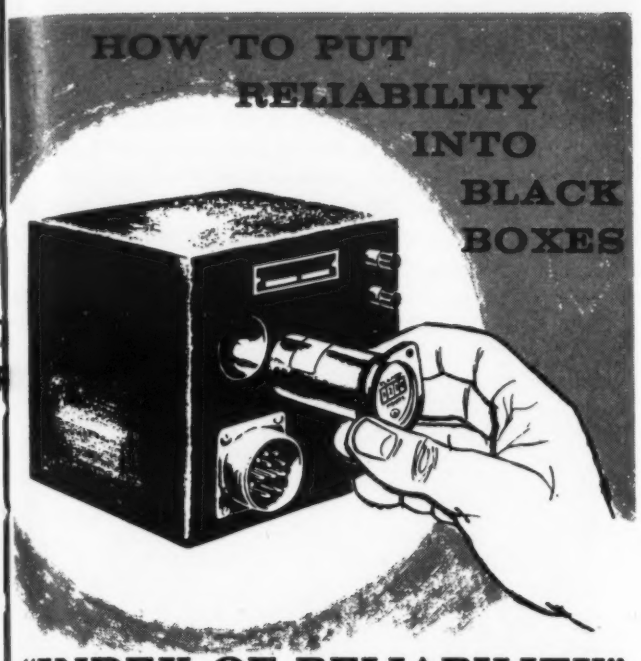
SPECTRUM ANALYSIS FILTER

New Rayspan Spectrum Analyzers, Type MRFR, each with 100 filters covering portions of the 50 cps to 100 kc spectrum, are available for shock



and vibration studies, acoustic studies, equipment inspection, speech analysis, transmission surveillance and telemetered data analysis. Full specifications on request.—*Commercial Apparatus & Systems Div., Raytheon Company, 1415 Providence Turnpike, Norwood, Mass.*

CIRCLE 154 ON READER-SERVICE CARD



"INDEX OF RELIABILITY" . . . Mean Operating Time Between Failures.

Reliability and Maintainability are always important — and most often very critical factors. Their definitions invariably involve "time". Some military specifications use "mean operating time between independent failures" as the index of reliability and call for the incorporation of elapsed time indicators into the operating equipment. Replacing critical components before they reach the limit of rated life contributes greatly to peak operating efficiency and reliability.

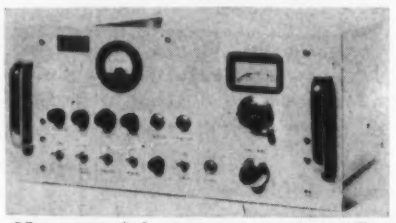
Waltham's subminiature elapsed time indicators are being used and designed into both military and commercial equipment for ground support and airborne applications. They are small and light enough to go anywhere. Jewel bearings, precision gear trains — some with a reduction of 1.8 billion to 1, a new low inertia synchronous motor are teamed with over 110 years of experience to provide instruments reliable and accurate enough to provide precise "measures of reliability".

Waltham can provide subminiature elapsed time indicators in both digital and dial readouts — and in production quantities. Write for bulletins #5001 and #5002 or telephone TW 3-4000

WALTHAM
PRECISION INSTRUMENT COMPANY
WALTHAM 54, MASSACHUSETTS

CIRCLE 55 ON READER-SERVICE CARD

AM-CW RECEIVER

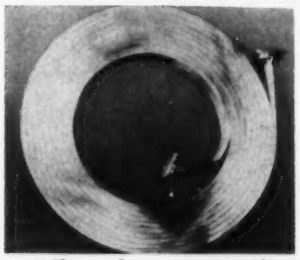


New special-purpose receiver Type 2501 for AM and CW reception has a tuning range of 55 to 260 mc designed for measuring the Doppler shifts of incoming signals, and features a low noise figure with uniform performance throughout the entire range.—*Nems-Clarke Co.*, 919 *Jesup-Blair Dr., Silver Spring, Md.*

CIRCLE 155 ON READER-SERVICE CARD

COMPACT X-BAND DELAY

New compact and lightweight X-Band waveguide delay lines are up to



50% smaller than conventional X-Band delays, but have same low loss and low reflection properties of the standard Turbo delay lines.—*Turbo Machine Co., Lansdale, Pa.*

CIRCLE 156 ON READER-SERVICE CARD

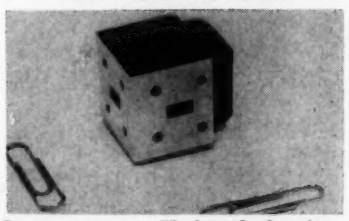
STRIP LINE CIRCULATOR

New X-band miniaturized strip line circulator has a minimum isolation

of 20 db and a maximum insertion loss of 0.4 db over a 6% band. Has VSWR of less than 1.4:1, handles 10w average power and 10 kw peak power. Input impedance is 50 ohms.—*Hycon Mfg. Co.*, 1030 *S. Arroyo Parkway, Pasadena, Calif.*

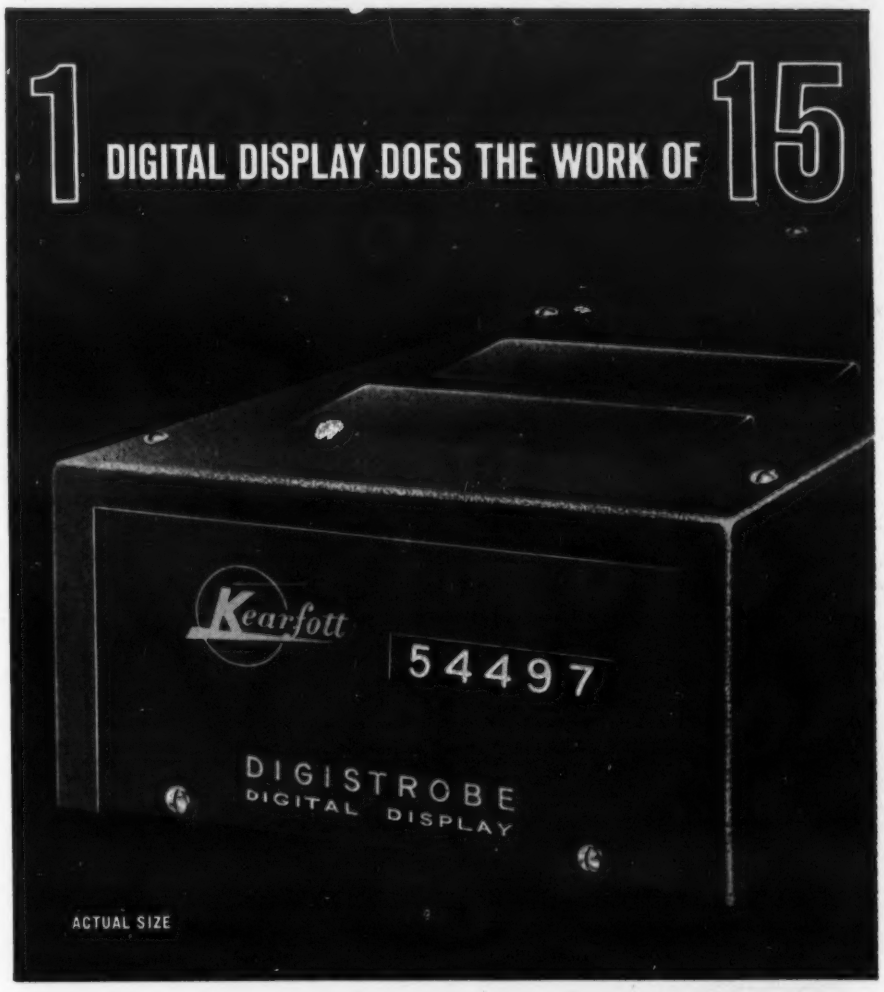
CIRCLE 157 ON READER-SERVICE CARD

TEE CIRCULATOR



New compact K_a-band ferrite microwave tee circulator will handle 20-kw peaks and average power of 20 watts. Isolation between channels is 20 db minimum and maximum VSWR is 1.20.—*Airtron Inc.*, 200 *E. Hanover Ave., Morris Plains, N. J.*

CIRCLE 158 ON READER-SERVICE CARD



NEW KEARFOTT DIGISTROBE* DISPLAY

Kearfott's new, highly compact Digistrobe digital display utilizes the stroboscopic principle to produce an exceptionally high-definition readout in the actual size shown here. Through the use of a unique shutter arrangement, a single diode-encoding matrix is shared by all columns (5 in the standard model), resulting in substantial savings in electronic components and circuitry. The fast response time of the Digistrobe (56 milliseconds transition from one five-digit quantity to a totally different one) permits a single unit to sample several different inputs on command through an input selector switch. Up to 15 individual displays of existing types can thus be replaced by a single Kearfott Digistrobe!

Incorporating only two moving parts and exclusively solid-state switching circuitry, the Digistrobe has extremely long life expectancy and requires minimum maintenance and service. Operation is directly from the output register of a computer, counter or allied equipment, eliminating the cost of intervening circuitry. Two years of extensive laboratory tests assure compliance with Kearfott's rigid standards of quality. For complete data and specifications, write for Digistrobe bulletin.

*Kearfott Trademark

KEARFOTT DIVISION
GENERAL PRECISION, INC.
Little Falls, New Jersey

CIRCLE 56 ON READER-SERVICE CARD

VARIABLE ATTENUATOR

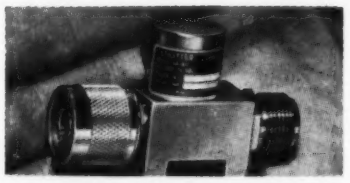
New low cost model of PI Line Continuously Variable attenuator, usable where large values of attenuation (over 10 db) are not required,

features 1.5 max VSWR for all attenuation values, max insertion loss of 0.5 db, 10 watt average power, over a range from 1.0 to 9.0 kmc. Either micrometer or shaft drive.—*Antenna & Radome Research Associates, 27 Bond St., Westbury, L. I., N. Y.*

CIRCLE 159 ON READER-SERVICE CARD

REMOTE ATTENUATOR

Remotely controlled, new coaxial unit is non-attenuating type "N" connector when control voltage is applied. Upon removal of operating

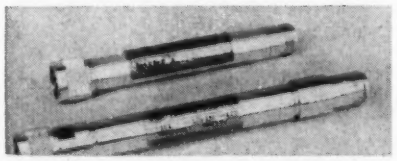


voltage, unit becomes a 20 db bi-directional attenuator usable from 50 mc to 3500 mc. Is available for 28 v dc or 115 v 400 cps operation; meets military environmental specs.—*Don-Lan Electronics Inc., 1131 Olympic Blvd., Santa Monica, Calif.*

CIRCLE 160 ON READER-SERVICE CARD

MINI COAX ISOLATORS

A complete line of miniaturized coaxial line isolators with no external permanent magnets cover frequencies from UHF to X-band. Three basic units designed for C, S, and L-



band operate over 10% bandwidths to provide more than 15 db isolation with less than 0.9 db insertion loss, weight 4, 5 and 6 oz respectively. Advantages claimed for new units are extremely small size and weight, excellent electrical performance and almost 100% shielding.—*Sperry Microwave Electronics Co., Clearwater, Fla.*

CIRCLE 161 ON READER-SERVICE CARD

Synchro Test Standard

Synchro testing conventionally has depended on the use of a control transmitter unit mounted in an index stand and used with a null detector to assure precise input signals. The Astrosystem Synchro Standard (see Figure) provides a test signal with a functional accuracy of 2 seconds of arc, which can serve as a base of reference for synchro testing or as an extremely accurate forward feed control input device for machine tools, computers, radar simulators and flight simulators.

When utilized in synchro testing, the new standard is manually switched to discrete positions. Elimination of the null detector and control transmitter in an index stand eliminates error due to operator misinterpretation.

Synchro standards are constructed with passive electromagnetic elements, fulfilling the requirements for military quality equipment and stability against deterioration of its initial accuracy. The Standards have been effectively used in qualification testing, production testing, production assembly testing and final system testing of synchros. They are a development of *Astrosystems, Inc., 220 East 23rd St., New York, N. Y.*

FOR MORE INFORMATION CIRCLE 162 ON READER-SERVICE CARD

Digital Products Section Forms New Firm

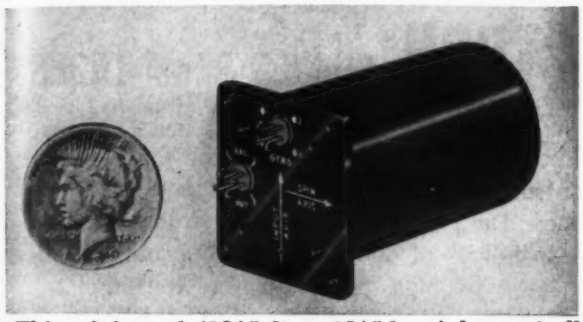
NATICK, MASS.—The digital and nuclear divisions of the Harvey-Wells Corporation, a wholly-owned subsidiary of Hercon Electronics Corporation, have expanded into two separate and independent organizations, the Harvey-Wells Corporation and Harvey-Wells Electronics, Inc. The Harvey-Wells Corporation, continuing as a Hercon subsidiary, will develop and manufacture electromagnetic and nuclear magnetic resonance product lines, many of which require numbers of multi-ton magnets, and will relocate where better facilities for such construction can be acquired.

The Harvey-Wells Electronics, Inc. is owned and operated by a newly-formed group, composed of key members of the digital division of the parent company, with Mr. J. W. Wood as president. This organization will specialize in the advancement of the parent organization's lines of high-speed "Data Bloc" and "Data-Pac" digital building blocks and related digital products. It will remain in the present modern manufacturing plant located in Natick, Mass., expanding its product digital development programs in phase with the relocation of the Harvey-Wells Corporation.

FOR MORE INFORMATION CIRCLE 163 ON READER-SERVICE CARD

Gyro Characteristics Vary to Meet Job Requirements

A new fluid-damped angular rate sensor having dynamic characteristics so controlled as to permit tailoring to the peculiar requirements of any customer, is the contribution of the R. C. Allen Aircraft Instrument Division.



This miniature[1] (1¾" dia x 3⅜" long) hermetically sealed unit employs a synchronous, hysteresis type motor supported on radial ball bearings, with gyro precession restrained by opposing beryllium copper leaf springs. Through variations of leaf thickness, the natural frequency is controlled, allowing selected angular momentum rates and/or gimbal deflection to act against the resulting spring rate and produce the desired sensitivity. Maximum angular rates from 0.05 to 10 radians/sec., undamped natural frequencies from 8 to 80 cps and angular momentum rates of 100,000 gm cm²/sec to 800.000 gm cm²/sec are coupled with excellent pickoff characteristics. Mounting flange (Fig. 1) is optional.

The microsyn pickoff provides output impedances of 10 to 2,000 ohms, 19v signal at maximum rate into 20K load and a 10 mv rms null voltage, with a minimum phase shift near null. Calibration curves of the pickoff produce a relatively sharp "V" at null.

The damper consists of opposing plungers operating in silicone oil within cupped chambers. Compensation for viscosity change due to temperature fluctuation is accomplished by selection of suitable material having different thermal coefficients for the piston and cylinder walls. A typical damping curve is shown in

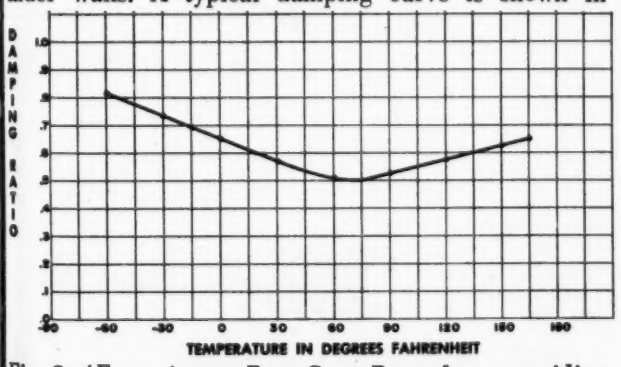


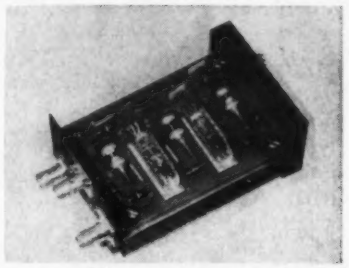
Fig. 2. (*From 4-page Rate Gyro Data sheet, providing environmental specifications.—R. C. Allen Business Machines, Inc., Aircraft Instrument Division,* 333 *Commerce Ave., S. W., Grand Rapids, Mich.*)

[1]*Editor's Note*: The manufacturer advises this rate gyro, with identical performance characteristics will be available in subminiature form (1-5/16" diameter x 1⅞" long) in approximately three months.

FOR MORE INFORMATION CIRCLE 164 ON READER-SERVICE CARD

MIXER-PREAMPLIFIER UNITS

New line of matched mixer preamplifier units gives optimum performance from a UHF system. Orion-matched mixer-preamplifier in

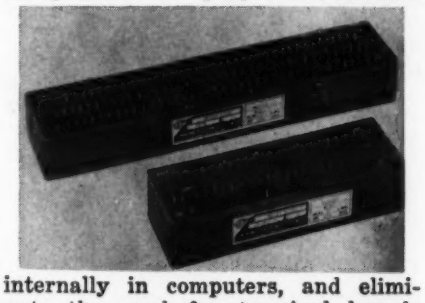


one assembly assures symmetrical bandpass, specified bandwidth, gain and noise figure.—*Orion Electronic Corp.,* 108 *Columbus Ave., Tuckahoe, N. Y.*

CIRCLE 165 ON READER-SERVICE CARD

COMPUTER-TYPE DELAY LINE

New lumped-constant delay lines Models F-577A (10-μsec delay) and F-578A (15-μsec delay) are totally encapsulated in epoxy resin, utilized



internally in computers, and eliminate the need for terminal boards which commonly trap moisture. Both have multiple taps, impedance of 400 ohms and operating temperature to 125°C.—*Control Electronics Co., c/o Delay Line Div.,* 10 *Stepar Place, Huntington Station, L. I., N. Y.*

CIRCLE 166 ON READER-SERVICE CARD

TEMPERATURE TEST CHAMER

New Model A-120-2-HC, providing over 2 cuft test volume with controllable temperatures from — 150°F to 300°F (± 2°) with indicating con-

troller. Recording and programming are optional features for production or R/D testing.—*Cincinnati Sub Zero Products,* 3932 *Reading Road., Cincinnati* 29, *Ohio*

CIRCLE 167 ON READER-SERVICE CARD

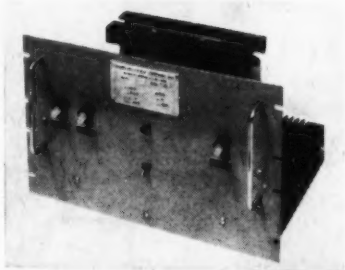
VARIABLE DELAY LINES

New Series 700 Miniature Variable Delay Networks provide time delays from ⅛ to 1.5 μsec with pulse rise

times from 0.03 to .30 μsec (max), 1.0 db max pulse attenuation. Networks are rated at 500 v dc max working volts.—*ESC Electronics Corporation, 534 Bergen Blvd., Palisades Park, N. J.*

CIRCLE 168 ON READER-SERVICE CARD

RECTIFIER

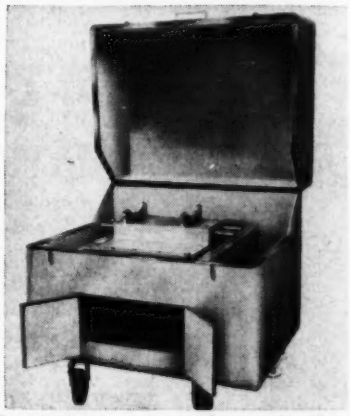


New compact convection-cooled power supply suitable for laboratory and industrial applications, Ramm Rectifier Model SB115-10 operates from 220/440 v to ±10%, 3-phase, 60-cycle power source; continuous duty output rating of 115-v dc at 10 amps. All components designed to withstand overloads up to 200%.—*Ramm Rectifier Co., Inc., 527 Faile St., The Bronx 59, N. Y.*

CIRCLE 169 ON READER-SERVICE CARD

PORTABLE VIBRATION TEST

New simplified "Rotocon" portable vibration tester for operation by factory quality control personnel provides a fundamental output at 50 cps

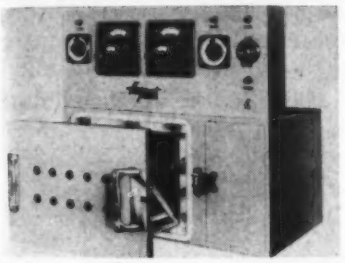


and overtones at predetermined multiples. To operate, bolt component to table of machine and turn on switch. Timer automatically turns off at end of test. Simple data take-off and other characteristics explained on request.—*Rototest Laboratories, Inc., 2803 Las Flores, Lynwood, Calif.*

CIRCLE 170 ON READER-SERVICE CARD

ENVIRONMENTAL CHAMBER

New table-top portable environmental chamber for testing and con-

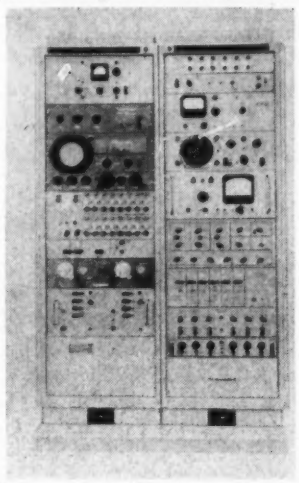


ditioning of electronic components is equipped with dual timers for automatic cycling of electric heat and liquid CO_2 cooling without constant control adjustment. Temperature range —100°F to 400°F (± 1°F) allows hot-cold shock to —100°F in seconds. Chamber is 14" x 10".—*The Electric Hotpack Co., Inc.,* 5060 *Cottman St., Phila.* 35, *Pa.*

CIRCLE 171 ON READER-SERVICE CARD

RANDOM VIBRATOR CONTROL

New Model 1011 System controls any power amplifier and shaker com-

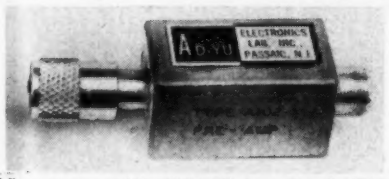


bination to provide true random vibration to match any test specification.—*Genisco, Inc.,* 2233 *Federal Ave., Los Angeles, Calif.*

CIRCLE 172 ON READER-SERVICE CARD

INSTRUMENT PREAMPLIFIER

Miniature transistorized preamplifier, Type A102 provides sensitivity gain of 100 by connecting it between input signal and laboratory instrument. Bandwidth is flat within 3 db from 10 cps to 80 kc, max output is



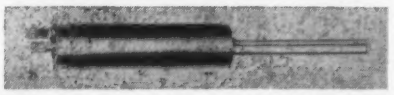
2.5 v rms with 100 Kohm load. Two amplifiers can be used in tandem for gain of 10,000 without oscillation. Uses one 15 v radio type battery with operational life of 1,000 hours.—*Ad-Yu Electronics Lab., Inc.,* 249-259 *Terhune Ave., Passiac, N. J.*

CIRCLE 173 ON READER-SERVICE CARD

CIRCLE 62 ON READER-SERVICE CARD →

TUBULAR RELAY

New tubular design having only one moving part (armature) features simplicity with very high reli-



ability—life of more than 200 million mechanical operations. Hermetic sealed and nitrogen filled, it meets 15 G vibration, 10 to 2000 cps, 30 G shock de-energized, 100G shock energized with no contact opening. Complete technical data on request.—*Wheelock Signals, Inc., Long Branch, N. J.*

CIRCLE 174 ON READER-SERVICE CARD

DICE-CUBE RELAY

New half-inch cube SPDT relay meeting all MIL-specs for relays of this size have terminals for 0.100" grid mounting, ratings from dry circuit to 1 amp resistive, temperature −65° to 125°C. One pin is off set for keying. *Hi-G, Inc. Bradley Field, Windsor Locks, Conn.*

CIRCLE 175 ON READER-SERVICE CARD

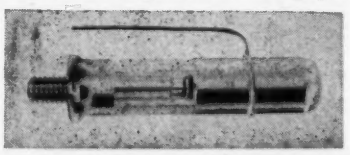
MINIATURE AIR CAPACITOR

New Type 2951 capacitor, less than ½" long is fully adjustable from 0.8 to 10.0 mmf. Used in missiles, computers, and other electronic devices requiring fine tuning.—*Johanson Mfg. Corp., 400 Rockaway Valley Rd., Boonton, N. J.*

CIRCLE 176 ON READER-SERVICE CARD

QUARTZ SEALCAP TRIMMER

New miniature high-voltage high-temp quartz sealcap trimmer features capacitance range of 2 to 10 pf, 3000

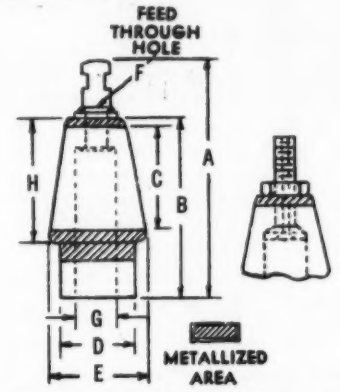


vdc working voltage, 5000v dielectric strength; 2 x 10^6 megohms insulation resistance; temp coefficient of ± 50 ppm/° C; Q of 1500 at 1 mq.—*JFD Electronics Corp., 6101 16th Ave., Brooklyn 4, N. Y.*

CIRCLE 177 ON READER-SERVICE CARD

Metalized Ceramic Insulators

A silver fired coating on terminal areas of ceramic insulators now enables manufacturers of capacitors and transformers, etc., to efficiently make connections at test voltages to 15,000 V and still maintain hermetically sealed units.



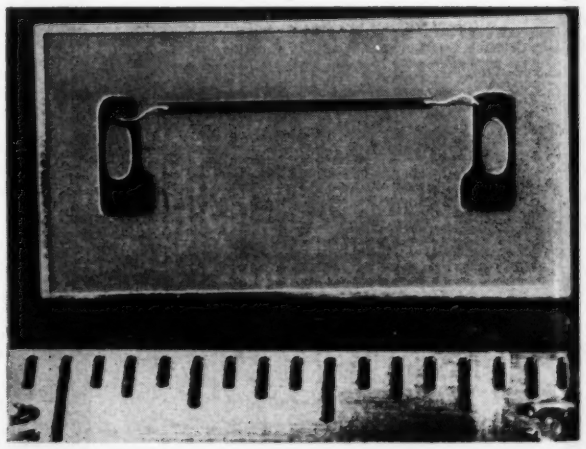
Soldering to the metalized portion of the ceramic terminal is easily accomplished. This tinned metalized coating will withstand 450° for 1½ minutes. When used in feed-through applications the solder provides complete sealing at the base and at the feedthrough hole of the insulator (See Figure). (*From 2-page technical Bulletin M-102, Metalizing Industries, Inc., 338 Hudson St., Hackensack, N. J.*)

FOR MORE INFORMATION CIRCLE 178 ON READER-SERVICE CARD

Bondable Semiconductor Strain Gage

New Micro-Sensor bondable semiconductor strain gage Model MS 105-350 for microstrain measurement in all types of military space and industrial systems are now available in production quantities from Micro-Systems, Inc., 2925 East Foothill Blvd., Pasadena, Calif.

The new strain detection device (see Figure) measuring 1" x ½" utilizes a thin silicon element only ½" long and .0005" thick attached to an epoxy-based carrier for application to test surfaces, provides an output 50 to 60 times greater than bondable metallic strain gages. Also its impedance is low, resulting in a high signal-to-noise ratio.



SOLIDSTATE Strain Gage provides over fifty times the output of bondable metallic strain gages.

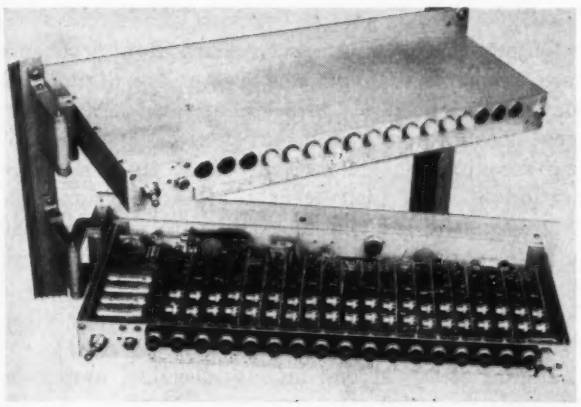
The new semiconductor strain gage is the product of a two-year research and development program conducted by the Solid State Division of Electro-Optical Systems, parent company to Micro-Systems, Inc. Its gage factor is said to be approximately 130.

The current operating temperature range is from —65° to 180°F for the Model 105-350, and higher temperature models are in advanced development stages. Resistance is 350 ohms, with a maximum operating strain of over 3000 microinches per inch.

FOR MORE INFORMATION CIRCLE 179 ON READER-SERVICE CARD

Fault Monitor Scans Thirty Remote Stations

New transistorized fault alarm developed by the Texas Division, Collins Radio Co., Dallas 7, Tex., is capable of reporting 11 or 17 different fault conditions from each of as many as 30 remote microwave stations. Shown in the accompanying illustration, a transmitter (upper unit) at each remote station continuously scans for faults and simultaneously reports all faults present to its associated receiver at a supervisory station (but here shown as lower unit) every four seconds by means of a single AM tone.



Tones are spaced at intervals similar to FSK telegraph and can be set within one of five ranges between 1 and 30 kc. The number of stations reporting over a single communication channel may be increased at any time by adding transmitter and receiver pairs and tuning them to unused frequencies.

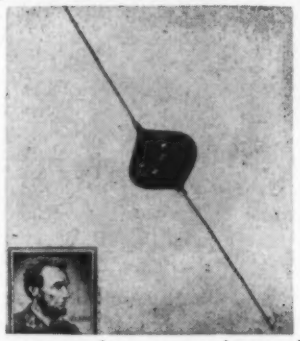
Fault reports are displayed at both the transmitter and receiver by front panel indicator lights, with a separate light for each fault. A remote alarm signal is also provided by the receiver. Transmitter outputs may be bridged directly on the baseband, while receiver inputs may be bridged on an isolation amplifier or service channel output. In addition to fault reporting, the transmitter and receiver may be used for binary data communication or remote control. In very large systems, the transmitters and receivers may be arranged for automatically interrogated operation.

Each transmitter and receiver unit is housed in a single plug-in module, 1½" high, 7" deep and 18" wide. Plug in subassemblies are also used to permit easy maintenance. Only 20 watts of power are required for operation, due to the completely transistorized circuitry.

FOR MORE INFORMATION CIRCLE 180 ON READER-SERVICE CARD

"GUM DROP" TOROID

New miniature "gum drop" epoxy encapsulated toroid in the 2 kc to

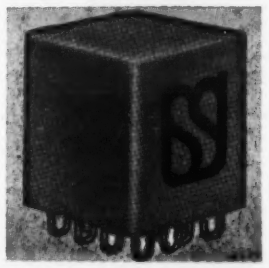


25 kc range has a maximum inductance of 2 hy. Toroids feature high Q, excellent stability vs temperature and current, self shielding and high L-to-volume ratio. Meet MIL-T-27A. —*Cinema Engineering*, 1100 *Chestnut St., Burbank, Calif.*

CIRCLE 181 ON READER-SERVICE CARD

CUBE-SHAPED RELAY

New 4-PDT 2-amp crystal case relay meeting MIL-R-25018 and MIL-R-5757C is packaged in a case 0.800" square and 0.875" high. It will be

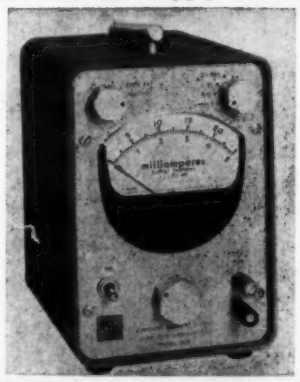


produced in quantity by early spring, 1961, and will occupy the same chassis space as two DPDT crystal case relays mounted side by side.—*Union Switch & Signal Div., Westinghouse Air Brake Co., Pittsburgh* 18, *Pa.*

CIRCLE 182 ON READER-SERVICE CARD

CONSTANT CURRENT SUPPLY

New Model 151B transistorized constant current supply covers 0.05



to 500 ma in four ranges, regulated to within 0.25% for 0-20 volts load and 105-125 volt line. Particularly useful for semiconductor testing, potentiometer and sensitive relay tests, also strain-gage systems.—*Quan-Tech Laboratories, Inc., Boonton, N. J.*

CIRCLE 183 ON READER-SERVICE CARD

VOLTAGE REGULATOR

New solid-state miniature voltage regulator for space vehicles accepts unregulated 24 to 32 volts dc and provides a regulated voltage of 16 to 18 volts (customer adjusted). For load currents up to 100 ma, the output voltage is constant within 300 mv.—*Acton Laboratories, Inc. Space Instrumentation Div., 533 Main St., Acton, Mass.*

CIRCLE 184 ON READER-SERVICE CARD

HI-VOLTAGE DIVIDER

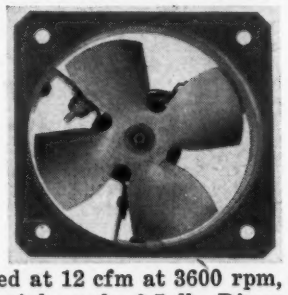
A new record in high-precision high-voltage divider was set when a 300:1 ratio network of 30-megohm resist-

ance for use on 30,000 volts was specified by a special order customer to operate at 0.05% accuracy. Large divider, here compared with a conventional small resistor network, actually maintained voltage division within 0.01%, believed to be a new record in this size divider.—*Resistance Products Co., 914 So. 13th St., Harrisburg, Pa.*

CIRCLE 185 ON READER-SERVICE CARD

MINIATURE COOLING BLOWER

New all-aluminum axial blower Unit MSA-11050 has a 60-cps motor,

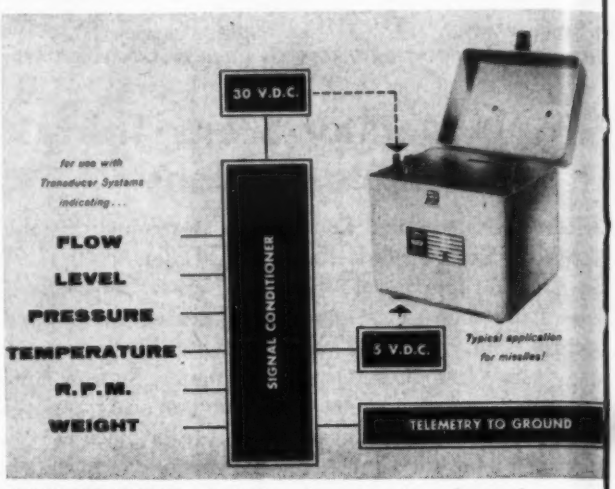


is rated at 12 cfm at 3600 rpm, specs, and weighs only 0.5 lb. Dimensions: 2.94" wide, 3.44" high, and 3.50" deep.—*Specialty Blower Div., Torrington Mfg. Co., Torrington, Conn.*

CIRCLE 186 ON READER-SERVICE CARD

Multirange Digital Voltmeter Reads Missile Transducers

A new portable multirange digital-indicating voltmeter, designated Model BH190, available in 4 ranges covering from 0-.020 v to 0-10,000 v dc, is adapted to many uses in flight and ground support testing of missiles.



MULTIRANGE digital voltmeter is adapted to missile tests.

Outputs from transducers sensing flow, level, pressure, temperatures, rpm and weight are digitally displayed to an accuracy of 0.1% of range. Each instrument is calibrated to an accuracy of better than 0.05% and resolution is better than 0.02%. Individual calibration of each instrument to this precision is accomplished by a mylar tape slidewire 144" in length in which sprocket holes are variably spaced to linearize up to 13% input deviation. This tape actuates the digital readouts. When the input deviation is greater than 13%, printed tape presentation is used.

Digital electrical and analog electrical outputs are available for telemetry systems of any type, making this instrument particularly useful in the checking of telemetry units at all points in the missile launching complex. (*From 4 page Technical Bulletin BH190 DC Digital Voltmeter, Howell Instruments, Inc., 3479 West Vickery Blvd., Fort Worth 7, Texas, formerly the B&H Instrument Co., Inc., of the same address.*)

FOR THIS LITERATURE CIRCLE 187 ON READER-SERVICE CARD

Function Error in a Computing Resolver

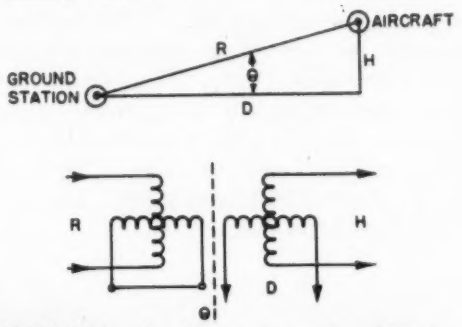
A computing resolver is a rotatable transformer whose output obeys the equation

$$E_{o1} = K_1 E_{i1} \sin \theta$$

where θ is the rotor angle relative to the stator and K is the complex transformation ratio.

When it is necessary to compute this simple trigonometric function in an analogue computer, the computing resolver is employed. For most applications such a computation is too elementary, so another output winding is added permitting the design engineer to simultaneously utilize both a sine and cosine function, and for complete flexibility in computation, sti

another input winding is added (See Figure). Such is the general winding configuration when one speaks of computing resolvers.



RESOLUTION of Distance and Altitude from Slant Range is simple problem for resolver.

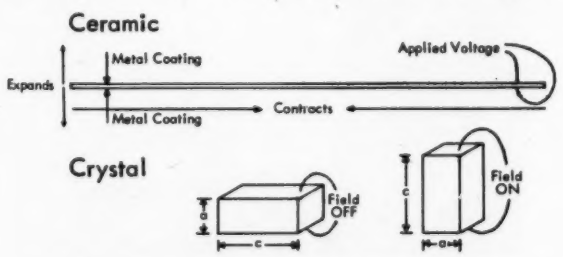
Compensated resolvers are still more sophisticated. The objective of compensation is to produce a complex transformation ratio which is virtually independent of temperature and impedance loading. Several techniques are used, but the schematic and equations shown above still comprise the basic computing resolver. (*From* 16 *page monograph "A Primer for Computing Resolvers" by Theta Instrument Corp.*, 520 *Victor Street, Saddle Brook, N. J.*)

FOR THIS LITERATURE CIRCLE 188 ON READER-SERVICE CARD

Electrostrictive Ceramics are New Motor Elements

Electrostrictive ceramic changes dimensions when an electric field is applied. The ceramic, prepared from modified barium titanate, expands parallel to the field and contracts perpendicular to the field, as shown in the sketch. Electrostrictive ceramic is prepared in thin, flat sheets so that a high voltage gradient is readily obtained.

Motion data given in the table is typical of a 5 mil thick specimen and is independent of the polarity of the applied field. No pre-polarization is required.

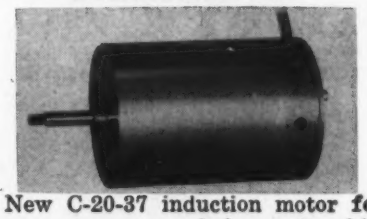


TYPICAL CONTRACTION FOR 3" LENGTH							
Volts/Mil	12.5	25	37	50	63	75	88
Mils of Motion	0.2	0.5	0.75	1.0	1.25	1.45	1.5

Motor elements, or Capadynes, in beam, disc and stack types, have been developed utilizing electrostrictive ceramics. Other uses for this new material are for memory units and thermal voltage converts. Dielectric constant is about 2000. (*From set of four* 1-*page technical data sheets, Electronic Dept., Mullenbach Division, Electric Machinery Mfg. Co.*, 2100 *East 27th St., Los Angeles* 58, *Calif.*)

FOR THIS LITERATURE CIRCLE 189 ON READER-SERVICE CARD

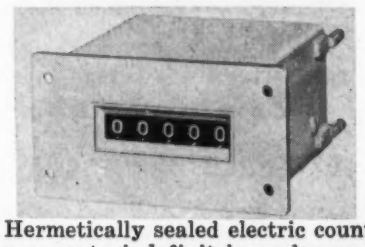
BLOWER MOTOR



New C-20-37 induction motor features extreme speed, low noise, high efficiency, precision balance, and superior quality. Features: ¾ hp, 200-v 400-cps, 22,300 rpm, 2.83 oz-ft torque. —*Kearfott Div., General Precision*, 1150 *McBride Ave., Little Falls, N. Y.*

CIRCLE 190 ON READER-SERVICE CARD

SUBMERSIBLE COUNTER



Hermetically sealed electric counter can operate indefinitely under water because electric reset mechanism is sealed. Model 5-YE-9156-ER is high speed unit running to 2400cpm and resetting in 105 msec.—*Durant Mfg. Co.*, 1981 *No. Buffum St., Milwaukee* 1, *Wis.*

CIRCLE 191 ON READER-SERVICE CARD

LINT-FREE COVERALL

New lint-free, static-free, acid-resistant Coverall featuring streamline pattern for plant safety, is made of white herringbone Dacura, a blend of polyester fiber and rayon. Details in six-page folder.—*Angelica Uniform Co.*, 1427 *Olive St., St. Louis* 3, *Mo.*

CIRCLE 192 ON READER-SERVICE CARD

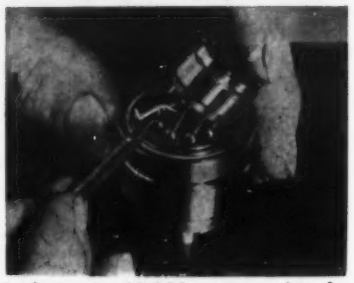
FRAMING CAMERA GEARHEAD

New gearhead for portable, continuous-writing Model 326 Dynafax framing camera takes 7100-rpm input from a small motor and steps it up to 100,000 rpm for fast mirror rotation.—*Bowmar Instrument Corp.*, 8000 *Bluffton Rd., Ft. Wayne, Ind.*

CIRCLE 193 ON READER-SERVICE CARD

HYDRAULIC PUMP

New Model 905 piston-type hydraulic pump operates at 40,000 rpm, is 2.5" dia x 2.7" long and delivers

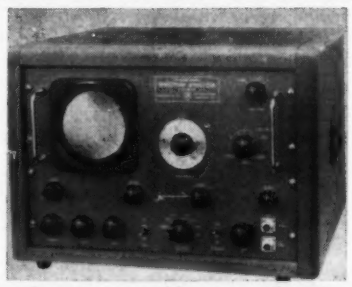


13.1 hp at 40,000 rpm. At lower speeds the pump has a volumetric efficiency of 98% and an over-all efficiency of 90%. Flow response is 30 msec or less.—*Vickers Inc., Div. of Sperry Rand Corp., Detroit 32, Mich.*

CIRCLE 194 ON READER-SERVICE CARD

EXTENDED RANGE ANALYZER

New high resolution spectrum analyzer, Model MD-500, accomplishes separation of signals only 10 cps apart in the 450 kc to 100 mc range.

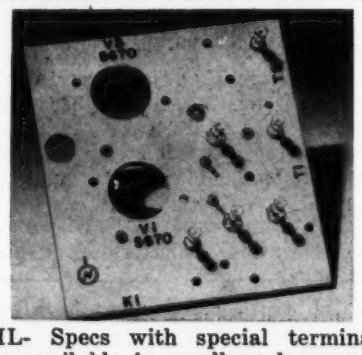


Two inputs provide use of external oscillator to automatically scan the difference frequencies in such applications as single sideband monitoring, FM modulation, parasitic oscillations and power frequency hum. Complete specifications on request.—*Probescope Co., Inc.,* 8 *Sagamore Hill Drive, Port Washington, N. Y.*

CIRCLE 195 ON READER-SERVICE CARD

TERMINAL BOARDS

Custom designed terminal boards from silicone, melamine, epoxy or other laminates to meet customer and



MIL- Specs with special terminals are available in small or large production runs.—*Special Products Div., National Connector Corp.,* 311 *Fifth Ave., North, Minneapolis* 1, *Minn.*

CIRCLE 196 ON READER-SERVICE CARD

A Pocket Laboratory Scope

Designed to be the answer to a busy field engineer prayer, the new EI Lab Model 150 Oscilloscope offe a number of interesting examples in transistorize design. Five circuit boards (Fig. 1) plug into a mothe board, which in turn is incorporated in an anodize aluminum case with a front panel assembly and a rea panel assembly in an overall size of 2¾" x 3¼" x 5½ (Fig. 2). Electro Instruments, Inc., is located at 116 Morena Blvd., San Diego 10, Calif.

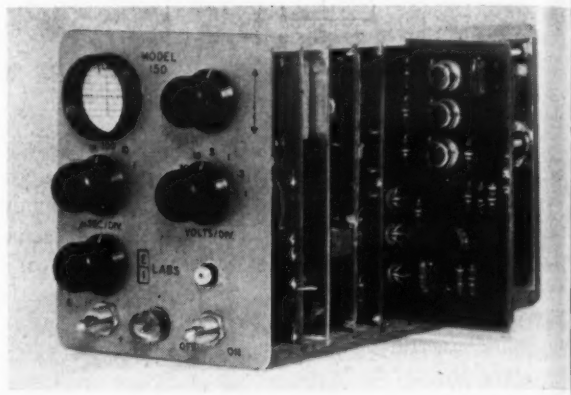


FIG. 1. MINIATURE SCOPE with full-scale performance utilizes printed circuit ultra compact construction made possible by transistorization and high definition 1" CRT.

FIG. 2. FIELD ENGINEERS show high interest in extremely portable, battery-powered oscilloscope they can carry in their brief case. 2" model is shown in background.

Small size, moreover, is accomplished without sacr fice of excellent performance characteristics, due ingenious circuitry arrangements. The vertical defle tion amplifier is direct coupled with a typical ban width of dc to 3 mc and a vertical sensitivity of 1/1 v/div. Input impedance is 1 megohm shunted by 20 p The use of a physical input resistor prevents injury t the first transistor if the input should be overloaded.

The input vertical attenuator mounted on the fro assembly panel serves to attenuate the signal to th

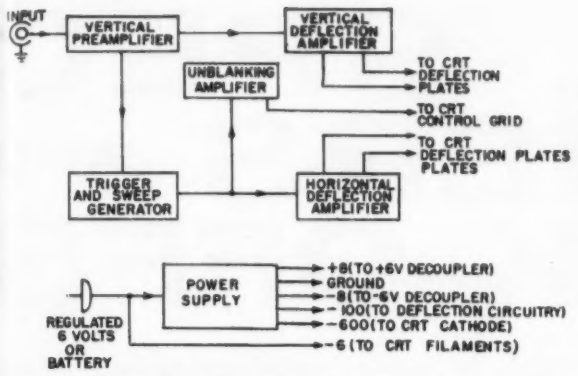


FIG. 3. BLOCK DIAGRAM of Electro Instrument Laboratory Model 150 Oscilloscope agrees closely with the organization of the circuitry on five printed circuit cards.

proper level for the first circuit board, the vertical preamplifier.

Because of the broad-band characteristics desired for this attenuator and the small amount of space available, an unconventional design was necessary. By using matched fixed capacitors, with a single fixed value of resistance plus one trim value for each range, the desired dc to 3 mc band-pass is achieved (Fig. 3).

The output impedance of the vertical preamplifier is quite low and feeds the main vertical deflection amplifier and the trigger and sweep circuit board (Fig. 4). The vertical deflection amplifier positions the display and amplifies the signal to give full-scale vertical deflection on the CRT. The signal going to the trigger and sync generator is coupled into an inverting amplifier which can provide either plus or minus signals to the trigger generator.

The horizontal sweep may be triggered at any point on the slope of a negative or positive going signal of one-half division or more in amplitude. The sweep may also be made to free-run by adjusting the trigger slope control, and will sync onto a fast-recurring signal. Sweep speed is variable from 1 μsec/div to 10 msec/div, and all normal CRT adjustments are available.

The internal rechargeable battery provides continuous operation for two hours and for longer intermittent periods. It can also be powered from an external six-volt battery. (*Schematic circuits of the Horizontal Deflection Amplifier and the Power Supply are discussed in the Circuitry Section of this issue, page* 16).

FOR MORE INFORMATION CIRCLE 103 ON READER-SERVICE CARD

BOOK REVIEWS (*Cont. from page* 23)

TRANSISTOR MANUAL, by H. R. Lowry, Manager, and others, Semiconductor Products Dept., General Electric Company, Kelley Bldg., Liverpool, N. Y., Fifth Edition (1960) 329 p., 5½" x 8½", $1.00. New chapters on Tunnel Diode Theory, Switching Circuits, Tunnel Diode Amplifiers, Feedback and Servo Amplifiers and Test Circuits. Specifications and interchangeability information on American JEDEC-registered transistor types.

FOR THIS LITERATURE CIRCLE 197 ON READER-SERVICE CARD

INTRODUCTION TO MODERN NETWORK SYNTHESIS, by M. E. Van Valkenburg, (1960) John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 498 p., 5½" x 9", $11.75. Basic methods of modern network synthesis, including applications to communications and automatic control systems.

FOR THIS LITERATURE CIRCLE 198 ON READER-SERVICE CARD

TAB TERMINAL SWITCHES

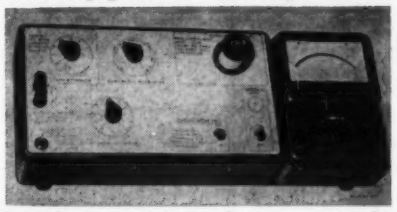
New aircraft-type toggle switches meeting all Mil-Specs are available

in complete line of single- and double-pole units having ¼" wide male tab connections.—*Kulka Electric Corp., 633-643 S. Fulton Ave., Mt. Vernon, N. Y.*

CIRCLE 199 ON READER-SERVICE CARD

INCREMENTAL MULTIMETER

New Tensor 5880 Incremental Multimeter enables increments of any range of the unit to be expanded about any point in the range and dis-



played on an external servo recorder. Range consists of over 50 different values of current, voltage, resistance, audio power, temperature, and transistor characteristics. Typical accuracies are 1.5% dc and 2% ac.—*Tensor Electric Development Co., Inc.,* 1873 *Eastern Parkway, Brooklyn* 33, *N. Y.*

CIRCLE 200 ON READER-SERVICE CARD

ALUMINUM CABLE CONNECTORS

New Cold-Forged aluminum connectors for aluminum aircraft cables exceed Mil-specs. Electro-tin plated

surfaces over high-purity aluminum provide contacts operating 20°F less than cables used on.—*The Thomas & Betts Co., 36 Butler St., Elizabeth, N. J.*

CIRCLE 201 ON READER-SERVICE CARD

AMPLIFIERS

New M2201-A broadband X-band traveling-wave tube amplifier for test instrument application is designed as a direct electrical and mechanical replacement for use in the HP494A amplifier unit and operates over the 7.0-12.4 kmc frequency range.—*Microwave Electronics Corp., 4061 Transport St., Palo Alto, Calif.*

CIRCLE 202 ON READER-SERVICE CARD

Unique Vertical Gyro for Target Drones

A new vertical gyroscope, Model NV 3203F (Fig. 1) designed for stabilization control in drone missile targets uses a unique erection system. This technique uses two weighted vanes and four reaction nozzles mounted atop the rotor case containing the electrically driven rotor.

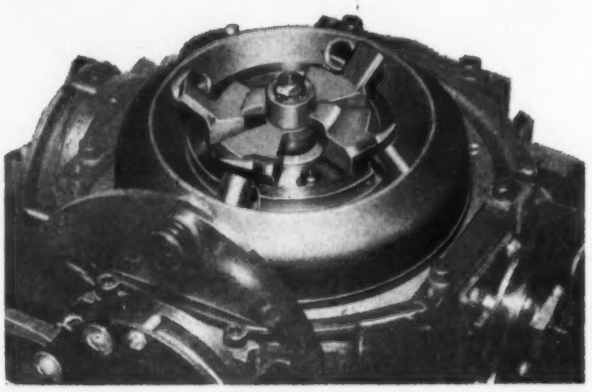


FIG. 1. REACTION jet nozzles, partially covered by unbalanced vane ends are shown in uncovered view of top of gyro, tilted toward the right. Weighted end of vane (far end) has uncovered its nozzle, while near end covers its nozzle, diminishing the air flow.

The inner gimbal, to which the pitch potentiometer is attached, is mounted in pitch axis bearings; and the outer gimbal, which holds the pitch axis bearings, has freedom on the roll axis provided by two similar bearings. A blower ring attached to the rotor forces air past the rotor and out of the four reaction nozzles.

When the gyro axis is vertical during a starting operation each vane leaf closes off half its accompanying air nozzle (Fig. 2). The resultant jet reaction forces are equal and opposite each other, equalling zero. When drift occurs and the top of the gyro tips forward, the weighted end of the pitch axis air control vane tips

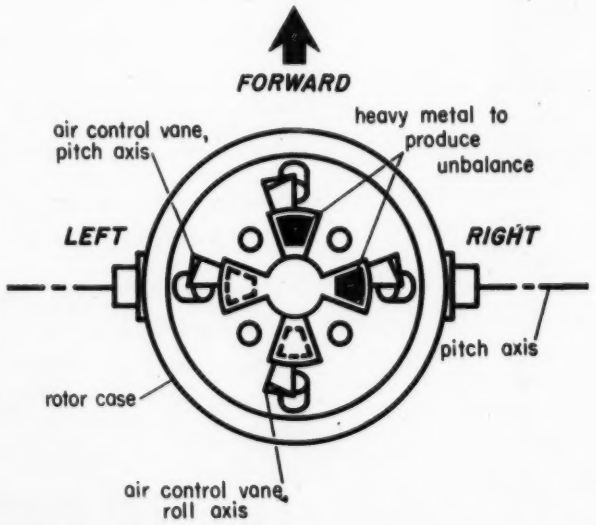


FIG. 2. ROLL and PITCH stabilization are separately controlled by four nozzles and two air control vanes for each axis.

forward, its valve leaf uncovering the right-hand jet orifice. At the same time the opposite valve leaf on the vane's unweighted end closes the left-hand orifice. The uncovered jet's reaction forces forces down the right hand end of the gimbal, causing the gyro to precess, returning the gyro axis to vertical. As the vane leaves again cover half the opposing jet pipes, the reaction forces are balanced and the starting position is again restored.

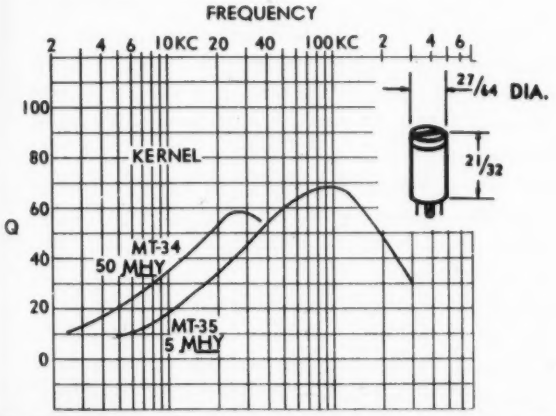
The method achieves true vertical within ±0.5° accuracy. The rugged construction withstands shocks of 30 G and vibration of 2 G to 1000 cps. Engineered for reliability and low cost rather than extreme miniaturization, the unit weighs approximately five pounds. It is a development of the Electronics Division, Iron Fireman Manufacturing Co., 2838 S. W. Ninth Ave., Portland 2, Ore.

FOR MORE INFORMATION CIRCLE 203 ON READER-SERVICE CARD

Toroid Applications Chart

For optimum performance of tuned circuits, phase networks and similar impedance devices, reactance must be an exact quantity. Even when the reactance is available in a fixed value capacitor or inductor, pick-up from other circuit components may change the frequency response of the impedance network.

To meet the needs for coils which would possess the prerequisites for providing exact reactance—high Q, low change in inductance with dc current variation, temperature stability and freedom from external field effects—Burnell & Co. pioneered in the development of the toroid.



DIMENSIONAL and characteristic data for ATE-34 Adjustoroid coil, .0001 to 1.00 hy.

Today, the toroidal type winding combined with molybdenum core advantages provides the standard for coil characteristics in audio applications particularly where small space and accessibility are important considerations. Another advantage of the toroid is its self-shielding properties which permit compact assemblies of coils in miniaturized networks with a minimum of deleterious effects from coupling. (*From 22" x 34" Coil Chart giving electrical and dimensional data on Toroidal Inductors. Coded in three colors for low, intermediate and high frequencies and with 20 applicable Q-Frequency characteristic graphs. Burnell & Co., Inc., 10 Pelham Parkway, Pelham, N. Y.*

FOR THIS LITERATURE CIRCLE 204 ON READER-SERVICE CARD

MSD new literature

PROXIMITY SWITCHES including control amplifiers are described in 8-page Catalog EDPS-80.—Electro Products Laboratories, Inc., 4501 Ravenswood Ave., Chicago 40, Ill.

CIRCLE 205 ON READER-SERVICE CARD

MICROPHONES, accessories, high-fi components, etc. are covered in 28-page Catalog 60A.—Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill.

CIRCLE 206 ON READER-SERVICE CARD

STRAIN GAGE, miniature Type HTM monofilament gage for use in crevices, fillets, etc. is described in 4-page data sheet 4331.—Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.

CIRCLE 207 ON READER-SERVICE CARD

SERVO MOTOR, hi-temp, size 8 precision, is detailed in 2-page Data Sheet 5004-09.—John Oster Mfg. Co., Avionic Div., Racine, Wis.

CIRCLE 208 ON READER-SERVICE CARD

SHAFT ENCODER. 12-page folder describes miniaturized shaft angle encoder, scan circuitry, and 8- and 13-digit analog to digital converter.—Litton Systems, Inc., 5500 Canoga Ave., Woodland Hills, Calif.

CIRCLE 209 ON READER-SERVICE CARD

TIME CODE GENERATOR for airborne application is described in 2-page Bulletin ZA-26211.—Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.

CIRCLE 210 ON READER-SERVICE CARD

SPECTRUM ANALYZER models are described in 8-page Bulletin 7-300.—Raytheon Co., Commercial Apparatus & Systems Div., Norwood 67, Mass.

CIRCLE 211 ON READER-SERVICE CARD

SERVO CONTROL simplification using Servoscope analyzer is illustrated in 2-page Bulletin NB-660.—Servo Corp. of America, 111 New South Rd., Hicksville, L. I., N. Y.

CIRCLE 212 ON READER-SERVICE CARD

QUARTZ Crystal Transducers for pressure, force, acceleration and vibration measurements are described in 20-page folio of data sheets.—Kistler Instrument Corp., 15 Webster St., No. Tonawanda, N. Y.

CIRCLE 213 ON READER-SERVICE CARD

DIGITAL TEST EQUIPMENT. (5000 Series) and System Building Blocks (6000 Series) are described in 6-page bulletin.—Digital Equipment Corp., Maynard, Mass.

CIRCLE 214 ON READER-SERVICE CARD

SINGLE-TURN wirewound precision pots for missiles, computer assemblies, calibration controls, etc., are described in 6-page catalog.—Fairchild Controls Corp., 225 Park Ave., Hickesville, L. I., N. Y.

CIRCLE 215 ON READER-SERVICE CARD

SUBCARRIER transistorized oscillator for telemetery is detailed in 4-page Model 0-20 folder.—Dorsett Electronics Laboratories, Inc., 119 West Boyd, Norman, Okla.

CIRCLE 216 ON READER-SERVICE CARD

SEMICONDUCTOR DIGITIZER applications have been compiled in 2-page Voldicon Bulletin.—Adage Inc., 292 Main St., Cambridge 42, Mass.

CIRCLE 217 ON READER-SERVICE CARD

VARISTORS and thermistors are described in 8-page catalog.—Victory Engineering Corp., 537 Springfield Rd., Union, N. J.

CIRCLE 218 ON READER-SERVICE CARD

ELECTRONIC CHOPPER, 2-page leaflet describes Model 70 silicon transistor chopper (or modulator).—Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.

CIRCLE 219 ON READER-SERVICE CARD

MAGNETIC CERAMIC devices are described in 2-page bulletin.—Lockheed Electronics Co., Avionics & Industrial Products Div., 6201 E. Randolph St., Los Angeles 22, Calif.

CIRCLE 220 ON READER-SERVICE CARD

SERVO MOTOR size 15, precision, hi-temp, Milspec Type is described in Data Sheet E 131A.—John Oster Mfg. Co., Avionic Div., Racine, Wis.

CIRCLE 230 ON READER-SERVICE CARD

SYNCHROS and Resolvers are listed in 4-page Condensed Catalog.—Vernitron Corp., 125 Old Country Rd., Carle Place, L. I., N. Y.

CIRCLE 231 ON READER-SERVICE CARD

ELECTRONIC industrial equipment is featured in new 576-page 1961 catalog.—Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.

CIRCLE 232 ON READER-SERVICE CARD

RADAR Pulse Modulator is described in 2-page MRC Data Sheet 30-116-0.—Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.

CIRCLE 233 ON READER-SERVICE CARD

MECHANICAL FILTERS. 2-page Bulletin CR-WD-1005 lists 90 filters in tabular form.—Collins Radio Co., Western Div., 2700 W. Olive Ave., Burbank, Calif.

CIRCLE 234 ON READER-SERVICE CARD

PULSE GENERATOR. 2-page Data Sheet 3352 details Cintel double pulse generator Model 3352.—Marconi Instruments, 111 Cedar Lane, Englewood, N. J.

CIRCLE 235 ON READER-SERVICE CARD

PRECISION CRYSTAL FILTERS are described in a kit of 8 leaflets.—Systems, Inc., 2400 Diversified Way, Box 7726, Orlando, Fla.

CIRCLE 236 ON READER-SERVICE CARD

L-CAP RF FILTERS are described in 8-page catalog.—Devco, Inc., 24 Maple Court, E. Longmeadow, Mass.

CIRCLE 237 ON READER-SERVICE CARD

SEMICONDUCTORS. 12-page brochure lists key specs of transistors, rectifiers, and diodes.—Motorola Semiconductor Products Inc., 5005 E. McDowell Rd., Phoenix, Ariz.

CIRCLE 238 ON READER-SERVICE CARD

TRANSISTORS AND DIODES, diffused silicon, are described in 4-page guide.—Schweber Electronics, 60 Herricks Rd., Mineola, L. I., N. Y.

CIRCLE 239 ON READER-SERVICE CARD

SILICON solar devices, transistors, diodes, zeners and SCR devices are described in 20-page catalog.—Semiconductor Div., Hoffman Electronics Corp., 1001 N. Arden Dr., El Monte, Calif.

CIRCLE 240 ON READER-SERVICE CARD

DIODE characteristics for Sperry Switching Types 1N690-1N693 and 1N920-1N923 are listed in 6-page Bulletin 2105.—Sperry Semiconductor Div., Sperry Rand Corp., South Norwalk, Conn.

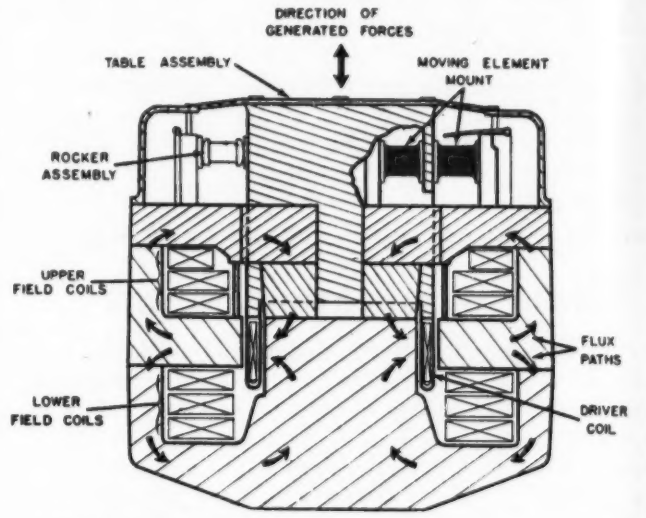
CIRCLE 241 ON READER-SERVICE CARD

DC TO DC Current Monitors for measuring flow of bus current up to 250 amps described in 2-page Data Sheet CM 9-1.—Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 242 ON READER-SERVICE CARD

Electrodynamic Shakers Calibrate Transducers

The MB Model C11 (50 lb force) and Model C12 (150-lb force) Calibrator-Shakers are designed to calibate accelerometers, velocity type pickups, displacement pickups, etc., over a wide range of frequency and acceleration, as well as to conduct vibration tests.



MAGNITUDE of generated force is proportional to ampere-turns of the movable coil at any instant.

The force generated in the electrodynamic type of vibration exciter (See Figure) is as pure as the current supplied from the power supply. In general either a power supply of the electronic amplifier or rotating electrical equipment type generates pure voltages without appreciable harmonic content and therefore produces currents in the vibration exciter which are mainly fundamental with little or no harmonic content. The generation of a sinusoidal force without harmonic content results; which allows the excitation of structures under tests without interference of response caused by harmonics.

The system best suited to test requirements is determined by the equation $F = Wg$, where F is exciter force rating, W is the moving weight (exciter table weight plus specimen weight) and g is acceleration in gravitational units. The force rating of the exciter should be sufficient to accommodate the range of testing to be accomplished.

The force generated is derived from a current flowing in the movable coil which is positioned in a region of high magnetic flux density, obtained by connecting the stationary field coil to a suitable dc voltage.

The magnetic structure offers a continuous path of low resistance to the magnetic flux except for the region occupied by the movable coil, where it crosses the wires of the movable coil. Accordingly, the direction of the generated force is as indicated in the diagram. It may be reversed by reversing the direction of current in the movable coil. (*From* 16*-page Bulletin, Products for Vibration Testing and Control," MB Electronics, A Division of Textron Electronics, Inc.,* 781 *Whalley Ave., New Haven* 8*, Conn.*)

FOR THIS LITERATURE CIRCLE 243 ON READER-SERVICE CARD

SECONDARY FREQUENCY standards and steel-tape program timers are described in a series of five 2-page bulletins.—Designers for Industry, Inc., 4241 Fulton Parkway, Cleveland 9, Ohio.
CIRCLE 244 ON READER-SERVICE CARD

PULSE GENERATORS in solidstate-9KW series for microwave applicators are described in 2-page Data Sheet.—Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.
CIRCLE 245 ON READER-SERVICE CARD

POST AMPLIFIERS, AFC UNITS. Discriminators, Detectors, Oscillators and Mixer-Preamplifier Assemblies are described in 8-page catalog.—Orion Electronic Corp., 115 Winding Brook Rd., New Rochelle, N. Y.
CIRCLE 246 ON READER-SERVICE CARD

BISTABLE AMPLIFIER specs and design data are presented in 4-page bulletin.—Norbatrol Electronics Corp., 356 Collins Ave., Pittsburgh 6, Pa.
CIRCLE 247 ON READER-SERVICE CARD

MINI OSCILLATOR, "C" band triode Model 151C, is described in 2-page Data Sheet C-2.—John Gombos Co., Inc., Webro Rd., Clifton, N. J.
CIRCLE 248 ON READER-SERVICE CARD

SWEEP OSCILLATOR covering 200 cps to 220 mc, having 3 beat-frequency bands, is described in 2-page leaflet.—Kay Electric Co., Maple Ave., Pine Brook, N. J.
CIRCLE 249 ON READER-SERVICE CARD

TOROIDS AND AMPLIFIERS. Two 4-page bulletins describe toroidal winding, inductor, and magnetic amplifier facilities; and stock servo and SCR control amplifiers.—Magnetico, Inc., 6 Richter Court, E. Northport, L. I., N. Y.
CIRCLE 250 ON READER-SERVICE CARD

MULTIPLE INPUT commutator-amplifier producing 5 to 10 v output from mv level sources is described in 4-page brochure.—San Diego Scientific Corp., 3434 Midway Dr., San Diego 10, Calif.
CIRCLE 251 ON READER-SERVICE CARD

DATA AMPLIFIERS for wideband transducer signals are described in new 8-page bulletin SCE-1.—Computer Engineering Associates, Inc., 350 N. Halstead, Pasadena, Calif.
CIRCLE 252 ON READER-SERVICE CARD

PREAMPLIFIERS. 4-page supplement (to Catalog 60) gives specs on microwave mixer-preamps, telemetry preamps, receivers, etc.—LEL, Inc., 75 Akron St., Copiague, N. Y.
CIRCLE 253 ON READER-SERVICE CARD

CATHODE RAY TUBES and recording storage tube types have characteristics listed in simplified chart.—William Weed, Raytheon Co., Industrial Components Div., 55 Chapel St., Newton 58, Mass.
CIRCLE 254 ON READER-SERVICE CARD

MICROWAVE TEST EQUIPMENT is described in 4-page brochure.—Waveline, Inc., Caldwell, N. J.
CIRCLE 255 ON READER-SERVICE CARD

COAXIAL TERMINATIONS for RG cable designed for tank mounting and for either cable-to-air or cable-to-oil operations are described in 2-page sheet.—Components for Research, Inc., 979 Commercial St., Palo Alto, Calif.
CIRCLE 256 ON READER-SERVICE CARD

RECEIVING TUBES. 11" x 17" chart lists Preferred Mullard electron tubes.—International Electronics Corp., 81 Spring St., New York 12, N. Y.
CIRCLE 257 ON READER-SERVICE CARD

SEMICONDUCTORS. 24-page Short Form Catalog covers over 800 diodes, rectifiers, etc.—International Rectifier Corp., El Segundo, Calif.
CIRCLE 258 ON READER-SERVICE CARD

CAPACITORS in polar or non-polar Tantalum foil and meeting MIL-C-3965 are listed in 4-page Bulletin 2625.—International Electronic Industries, Inc. Div., Standard Pressed Steel Co., Box S8, Jenkintown, Pa.
CIRCLE 259 ON READER-SERVICE CARD

WIRE-WOUND RESISTORS. 20-page Catalog 14 RE covers encapsulated and bobbin type units.—Cinema Engineering Div., Aerovox Corp., 1100 Chestnut St., Burbank, Calif.
CIRCLE 260 ON READER-SERVICE CARD

TRANSFORMERS, epoxy molded for transistor power supplies, are described in 6-page TY-61.—Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.
CIRCLE 261 ON READER-SERVICE CARD

SCR AMPLIFIERS and modular phase controllers for missiles, rockets and servo motors applications are described in 4-page bulletin 60711.—General Electronic Control, Inc., 8001 Bloomington Freeway, Minneapolis 20, Minn.
CIRCLE 262 ON READER-SERVICE CARD

MICROWAVE SYSTEMS. 8-page catalog explores applications of RT-3A heterodyne repeater for 2 kmc communications relay.—Adler Electronics, Inc., 1 Le Fevre Lane, New Rochelle, N. Y.
CIRCLE 263 ON READER-SERVICE CARD

MICROWAVE TUBES and components are described in 24-page short form catalog.—Bomac Laboratories, Inc., Salem Rd., Beverly, Mass.
CIRCLE 264 ON READER-SERVICE CARD

MINI CERAMIC CAPACITORS, 2-page Bulletin H-4 describes NARROW-CAPS to fit 1/10" modular spacing; 4-page Bulletin J-1 describes custom-made miniature ceramic capacitors.—Mucon Corp., 9 St. Francis St., Newark 5, N. J.
CIRCLE 265 ON READER-SERVICE CARD

POWER TRANSISTOR TEST SET, variable duty cycle, Model NC-1, is described in 2-page data sheet.—Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.
CIRCLE 266 ON READER-SERVICE CARD

CAPACITORS. 4-page bulletin details Series 38H and 38M plastic cased tubular capacitors.—John E. Fast & Co., 3598 N. Elston Ave., Chicago 18, Ill.
CIRCLE 267 ON READER-SERVICE CARD

VARIABLE CAPACITORS including tuning and trimming models are listed in 16-page Catalog 60.—Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.

CIRCLE 268 ON READER-SERVICE CARD

CAPACITORS. Series of four 2-page data sheets describe metallized Mylar capacitors, and metallized paper capacitors in epoxy tubes.—Electron Products Div., Marshall Industries, 430 N. Halstead St., Pasadena, Calif.

CIRCLE 269 ON READER-SERVICE CARD

LATCHING RELAY. 2-page Bulletin BR-594 describes BR-9 miniature, crystal-can sealed, 10-amp magnetic relay for aero-space and undersea applications.—Babcock Relays, Inc., 1640 Babcock Ave., Costa Mesa, Calif.

CIRCLE 270 ON READER-SERVICE CARD

RELAY MAINTENANCE is detailed in 8-page booklet.—P. K. Neuses, Inc., 511 N. Dwyer St., Arlington Heights, Ill.

CIRCLE 271 ON READER-SERVICE CARD

RELAYS. 4-PDT, 10 amp hermetically sealed BR-14 relay series meeting Mil Specs is described in 2 page Bulletin BR-595.—Babcock Relays, Inc., 1640 Babcock Ave., Costa Mesa, Calif.

CIRCLE 272 ON READER-SERVICE CARD

POWER SUPPLY. 8-page Catalog 120 lists specs and applications of mini power packs, transistorized frequency changers, solid-state power supplies, etc.—Electronic Research Assoc., Inc., 67 Factory Place, Cedar Grove, N. J.

CIRCLE 273 ON READER-SERVICE CARD

VOLTAGE REGULATORS. 8-page Catalog 4-265 provides spec data for 2,020 standard magnetic voltage regulator models.—Raytheon Co., Power Supply and Voltage Regulator Operations, Keeler Ave., So. Norwalk, Conn.

CIRCLE 274 ON READER-SERVICE CARD

POWER SUPPLY. 2-page Bulletin TT-160 describes compact 3½", regulated d-c power supplies.—Dynamic Controls Co., 2225 Massachusetts Ave., Cambridge, Mass.

CIRCLE 275 ON READER-SERVICE CARD

DC POWER MODULES transistorized and packaged for proper dissipation of heat are described in 4-page brochure. —Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.

CIRCLE 276 ON READER-SERVICE CARD

POWER SUPPLY. Transistorized dc unit with 0.0005% regulation is described in 4-page Bulletin 201.—Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 277 ON READER-SERVICE CARD

ENGINE and generator applications are described in 24-page brochure "Onan Mliitary Products Capabilities." —D. W. Onan & Sons, Inc., 2515 University Ave., S. E., Minneapolis 14, Minn.

CIRCLE 278 ON READER-SERVICE CARD

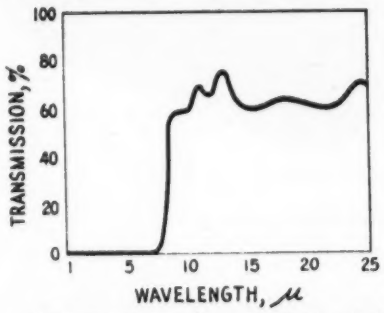
HERMETIC SEALS. 28-page Catalog 1259 lists types of precision hermetic seals.—Dage Electric Co., Inc., Beech Grove, Ill.

CIRCLE 279 ON READER-SERVICE CARD

Far Infrared Filters Have Sharp Cut-On

Isolation of infrared radiation out to 25 microns in wavelength is said to be possible with new interference filters developed by Spectracoat, Inc., of Belmont, California. These filters pass an average of at least 60% of the desired radiation but less than 1% of radiation in the rejection band. At present the cut-on point can be placed anywhere between 1.5 and 8.0 microns, as desired. Research to place the cut-on point at any point up to 16 microns is continuing.

The availability of infrared interference filters to the wavelengths beyond 8 microns extends the application of infrared detection and discrimination techniques to the possibility of identifying objects having a relatively small temperature difference from their background, over the thermal range of 110°C to —160°C, which is approximately the range from boiling water to liquid air.



SHARP CUT-ON is typical of a transmission curve for the new long-wave interference type infrared filter.

An important characteristic of the Spectracoat filters is their sharp cut-on (See Figure). Heretofore, the isolation of long-wave infrared has been by scatter or absorption filters, which have the undesirable characteristics of gradual cut-on and poor rejection. The cut-on slope of the new filters can be made considerably steeper—better than 13% of the cut-on wavelength.

The first use of the new long wave-length infrared filters is expected to be for military and astonomical purposes, but a growing use in industrial process control is anticipated.

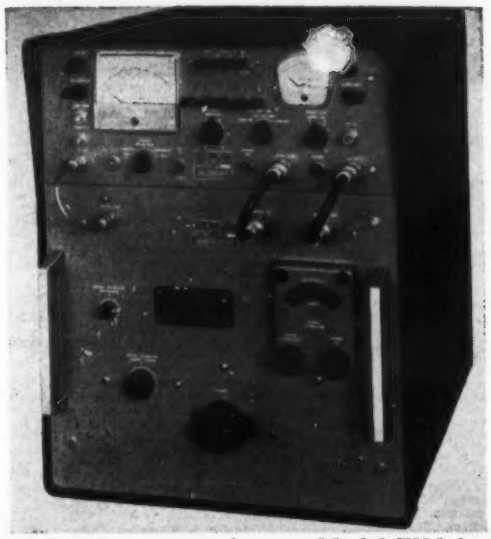
FOR MORE INFORMATION CIRCLE 280 ON READER-SERVICE CARD

Calibrated Field Intensity Meter

A completely redesigned Model FIM Microwave Calibrated Field Intensity Meter and Receiver was recently announced by the Polarad Electronics Corp., Long Island City 1, N. Y. Four interchangeable RF tuning units cover the 1000 mc to 10,000 mc range, and additional tuning units, presently under development will extend the range to 20,000 mc.

Intended for use in locating and measuring RF interference, field intensity measurements, determination of shielding effectiveness, propagation studies, RF leakage measurements, and the analysis of transmitters, receivers and other microwave components, it has been approved by US Air Force to perform radiation measurements under specification MIL-I-26600. Incorporating a self-contained power supply, its size and weight are greatly reduced over former

models. It also has a peak-indicating VTVM for location of impulse noise. All input signals can be attenuated up to 80 db in 1 db steps.



Rugged and compact, the new Model FIM features: Single-knob tuning control (UNIDIAL) tunes both the receiver and the signal calibrator; video, audio and recorder outputs; direct-reading frequency dial; signal generator function can be externally modulated; and calibrated narrow-band horn antennas and omnidirectional broadband antenna.

FOR MORE INFORMATION CIRCLE 281 ON READER-SERVICE CARD

Underwater Transducers

Underwater transducers and instruments designed for marine and oceanographic research and operations are among the products of the Hytech Corporation, Inglewood 3, Calif., including:

The Model 472 Telerecording Bathythermometer consists of an underwater unit which transmits two frequency modulated signals representing depth and temperature, and a surface unit which converts these signals into proportional dc voltages suitable for driving a two-function analog recorder.

The Model 370 Telerecording Savonius Rotor Current Meter consists of an underwater unit which transmits two FM signals representing current direction and velocity over a single insulated conductor with sea return, and a surface unit for driving indicator units.

The Swallow Type Expendable Underwater Pinger (See Figure) is a neutrally buoyant float which, when properly weighted, will sink to any predetermined depth and remain at that depth. It consists of a flotation tube which houses batteries and circuitry, and supports a magnetostrictive transducer which periodically emits an audible energy pulse in from 8 to 21 days. The position of the pinger can be determined by means of two or more suitably separated hydrophones. (*From 32-page catalog Hytech Corp., 6803 West Blvd., Inglewood 3, Calif.*)

FOR THIS LITERATURE CIRCLE 282 ON READER-SERVICE CARD

PNEUMATIC MOUNTS for supporting loads up to 30,000 lb/mount and to maintain absolute level within 0.00005 in/ft are described in Bulletin 60-05.1 (Serva-Levl Mount, series AM). Bulletin 59-04.5 describes 5200 series capable of 50 lb/mount.—Barry Wright Corp., 700 Pleasant St., Watertown 72, Mass.

CIRCLE 283 ON READER-SERVICE CARD

COMPRESSION TERMINALS. 6-page Bulletin SCT-60-101 lists g'ass-to-metal hermetically sealed term nals.—Electrical Industries, 691 Central Ave., Murray Hill, N. J.

CIRCLE 284 ON READER-SERVICE CARD

TUBING. 8-page Catalog 101 describes 8 types of insulating tubing and sleeving and zipper tubing.—Alpha Wire Corp., 200 Varick St., New York 14, N. Y.

CIRCLE 285 ON READER-SERVICE CARD

CERAMIC-TO-METAL sealing alloys available in air-or-vacuum-melted wire or strip are described in 6-page brochure.—Wilbur B. Driver Co., 1875 McCarther Highway, Newark 4, N. J.

CIRCLE 286 ON READER-SERVICE CARD

WIRING HARDWARE of all types listed in New 76-page Engineering Design Manual #212G.—TA Mfg. Co., Engineering Dept., 4607 Alger St., Los Angeles 39, Calif.

CIRCLE 287 ON READER-SERVICE CARD

DISCOVERER RECOVERY Program is summarized in 8-page PIB-52 booklet.—General Electric Co., Missile and Space Vehicle Dept., 3198 Chestnut St., Phila. 1, Pa.

CIRCLE 288 ON READER-SERVICE CARD

HYDRAULIC COMPONENTS. 8-page Bulletin 204 outlines use of hydraulic pumps, motors, and controls in missile ground support.—Denison Engineering Div., American Brake Shoe Co., 1160 Dublin Rd., Columbus 16, Ohio.

CIRCLE 289 ON READER-SERVICE CARD

AIR TRAFFIC CONTROL. 20-page booklet traces development of air navigation and automated controls.—General Precision Equipment Corp., 92 Gold St., New York 38, N. Y.

CIRCLE 290 ON READER-SERVICE CARD

CONTROL SYSTEMS. 6-page Bulletin EE-1008 describes electro-mechanical control systems and components for use on production machinery.—Seneca Falls Machine Co., Electronics Div., 12 Fyfe Bldg., Seneca Falls, N. Y.

CIRCLE 291 ON READER-SERVICE CARD

ELECTRO-OPTICAL shutters for speeds up to 10^{-9} sec for photographic and electronic instrumentation are described in 2-page leaflet.—Electro-Optical Instruments, Inc., 2612 E. Foothill Blvd. Pasadena Calif.

CIRCLE 292 ON READER-SERVICE CARD

MAGNETIC shield permitting more accurate magnetic testing of materials is described in Data Sheet 153.—Magnetic Shield Div., Perfection Mica Co., 1322 N. Elston Ave., Chicago 23, Ill.

CIRCLE 293 ON READER-SERVICE CARD

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MSD events

DECEMBER 13-15—1960 Eastern Joint Computer Conference, sponsored by IRE, AIEE and ACM, at the New Yorker Hotel, New York, N. Y. Write James L. Lanigan, Sylvania Electric Products Inc., 730 Third Ave., New York 17, N. Y.

JANUARY 8-12—1961 Symposium on Thermoelectric Energy Conversion, Statler-Hilton Hotel, Dallas, Texas. Jointly sponsored by IRE, AIEE, ANS, ARS, and others with the Department of Defense, Write Paul H. Egli, Chairman, Arrangements Committee, Naval Research Laboratory, Anacostia, D. C.

JANUARY 9-11—7th National Symposium on Reliability and Quality Control, Bellevue-Stratford Hotel, Philadelphia, Pa. Sponsored by IRE, IEE, and ASQC. Write James H. Goodman, RCA, Building 1-2, Camden 2, N. J.

JANUARY 12-13—Conference on Reliability of Semiconductor Devices, Western Union Auditorium, 60 Hudson St., New York. For information write Advisory Group on Electron Tubes, 346 Broadway, 8th Flr., New York 13, N. Y.

JANUARY 16-17—Symposium on Space Instrumentation scheduled to be held in Washington, D. C. has been CANCELLED.

FEBRUARY 2-4—Annual ISA North Central Area Automation Symposium, Radisson Hotel, Minneapolis, Minn. Write Ray Hoppen, Pub. Chairman, Minneapolis Honeywell, 621 E. Hennepin Ave., Minneapolis, Minn.

FEBRUARY 14-16—Second annual Symposium on Nondestructive Testing of Aircraft and Missile Components (unclassified), Gunter Hotel, San Antonio, Texas. Write R. B. Wangler, Gen Chairman, Southwest Research Institute, Box 2296, San Antonio, Tex.